Analysis of mentality traits in rhodesian ridgebacks

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PREFACE:

This thesis is the product of a life growing up with a special fascination for genetics and behavior in all animals, particularly in dogs. I never understood that it could be a science and a profession, before I stumbled upon a book by Eberhard Trumler on the school library at high school, and learned that my fascination actually had a name and later that I could choose to study it at two of the universities in Norway.

I am eternally grateful to the late professor Morten Bakken for being such a great and inspiring person, for leading me into ethology, for teaching me so many things about research and the critical and questioning mind and for being my mentor when I wrote my master thesis in ethology, a number of years ago. You will always be remembered!

When I decided to go ahead with another master, genetics and breeding pulled hard on me, but the choice of topic was not clear until I found that instead of choosing one among those proposed, I should go on with what interested me the most and form my own thesis.

I want to thank my three mentors – without any of you this would not be a reality! Thanks to Per Arvelius for providing the data and the knowhow, thanks to Tormod Ådnøy for being available on mail at almost any time of the day with technical, statistical and software assistance and thanks to Odd Vangen for very constructive comments, strict structure and all the experience needed for getting me through this. Sincerely thanks to all of you for letting me choose and decide for myself and for tagging along with (most of) my ideas!!

I also want to thank the Swedish Kennel Club for access to their data, the Swedish Rhodesian Ridgeback society for all help and positive attitude, and to all others who have answered my questions and been of assistance.

Huge thanks to my loving husband for letting me have this opportunity to learn and grow, I love you! Thanks to our beautiful daughter for being patient and understanding when mum had to go to school or work or could not come along on summer holiday. You are fantastic and the center of our lives!

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ABSTRACT:

The object of this study was to identify broader traits from mentality test results in a cohort of 2022 Rhodesian Ridgebacks , to estimate heritabilities for the underlying variables and the broader traits and to predict breeding values for these traits.

Data were extracted from the Swedish Dog Mentality Assessment between 1997 and 2012 on 2022 Rhodesian Ridgebacks. Analyses with a mixed model showed that sex, year and month of test, age category, litter, specific test situation and judge had significant influence on the test result, and was included in the model for estimation of heritabilities. These ranged from 0 to 0,22 with standard errors from 0,02 to 0,05.

With factor analysis, six factors were derived, describing the broader traits; 1 *Play*, 2 *Fear/exploration*, 3 *Chase*, 4 *Distance play*, 5 *Defense* and 6 *Sociability*. Heritabilities for these traits ranged from 0,09 to 0,31, they were all significant.

Breeding values were predicted based on these six traits, and genetic trends estimated for the birth years from 1989 to 2010, which showed an increase in average breeding values over the years for the factors 1, 3, 5 and 6, and a decrease in factors 2 and 4. For all factors but 4 this can be seen as improvements. Factor 4 being the distance play factor showing a decrease in exploration and play behavior over the years, which is hard to interpret in this breed.

Selection in this breed is not based on working abilities, and thus the selection intensity disappears among all breeders with separate agendas. Using indexes for the six broader traits may be of help when selecting animals for breeding, to maximize the chances of getting offspring who have the traits desired in a family dog of today, even if goals differ between breeders.

SAMMENDRAG:

Målet med denne oppgaven var å identifisere høyere egenskaper fra resultater fra mentalbeskrivelse for en gruppe på 2022 rhodesian ridgebacks, å estimere arvegrader for de underliggende variablene og de høyere egenskapene, samt å predikere avlsverdier for disse egenskapene.

Data ble hentet fra den svenske mentalbeskrivelse hund mellom 1997 og 2012 for 2022 hunder. Analyser med en mixed modell viste at kjønn, år og måned for test, alderskategori, kull, spesifikk testsituasjon og dommer hadde signifikant innflytelse på testresultatet, og alle disse ble inkludert i modellen for estimering av arvegrader. Disse lå fra 0 til 0,22 med standardfeil fra 0,02 til 0,05.

Ved hjelp av faktoranalyse ble seks faktorer utledet fra dette materialet, som beskrev følgene egenskaper; 1 *Lek*, 2 *Frykt/utforsking*, 3 *Jakt*, 4 *Avstandslek*, 5 *Forsvar* og 6 *Sosialitet*. Arvbarheter for disse egenskapene varierte fra 0,09 til 0,31 og de var alle signifikante.

Avlsverdier ble predikert på bakgrunn av disse seks egenskapene, og genetiske trender estimert for fødselsårene 1989 til 2010, som viste en økning i gjennomsnittlig avlsverdi gjennom årene for faktorene 1,3,5 og 6, og en nedgang for faktorene 2 og 4. For alle faktorene med unntak av faktor 4 er dette ønskelige resultater. For faktor 4, som er avstandsleken betyr det en nedgang i utforsking og lekelyst gjennom årene, og resultatet kan være litt vanskelig å konkludere hos denne rasen.

Seleksjon i denne rasen er ikke basert på bruksegenskaper, og dermed vil seleksjonsintensiteten forsvinne blant alle oppdrettere med egne agendaer. Ved å bruke indekser for de seks høyere egenskapene kan det være til hjelp når man skal velge ut avlsdyr, for å maksimere sjansene for å få avkom som har den atferden man ønsker i en familiehund i dagens samfunn, selv med ulike avlsmål hos de ulike oppdretterne.

TABLE OF CONTENTS:

ABBREVIATIONS:

FCI - Fédération Cynologique Internationale

DMA – Dog Mentality Assessment

SKC – Swedish Kennel Club

NKC – Norwegian Kennel Club

SRRS – Swedish Rhodesian Ridgeback Society

SWDA - Swedish Working Dogs Association

1 INTRODUCTION:

As more and more people live in densely populated areas, dog owners have an increasing responsibility to keep their dogs controlled and inflict no harm or problematic situations upon people who may be afraid or uninterested in dogs. This responsibility lies not only with the owner, but also with the breeders who provides people with these dogs, and who get paid for it.

In order to assess the future behavior of a dog, or the probable mental outcome of a mating, a breeder need a tool to assess dog mentality in a standardized way, with a reasonable chance of succeeding in improving the traits targeted.

Estimated breeding values may be a very good means to accomplish this, and if their estimations are based upon a reliable test, with reliable variance components, the genetic gain can be fast and breeding goals accurate.

There has not been estimated breeding values for Rhodesian Ridgeback earlier, and only one other breed has had breeding values estimated for mentality traits based upon the DMA (Arvelius 2012).

2 BREEDING FOR BEHAVIORAL TRAITS

2.1 Rhodesian Ridgeback:

The Rhodesian Ridgeback has its origin in Southern Africa, created by the Boer people in need of a guard- and hunting dog adapted to the harsh environment. It is categorized in FCI breed group 6 as a scent hound, but created from multiple imported and indigenous breeds approximately 100 years ago, this type of dog has characteristics from several breed groups; molossoids (FCI breed group 2), terriers (FCI breed group 3), pointing dogs (FCI breed group 7), scent hounds (FCI breed group 6) and sight hounds (FCI breed group 10) (Boyko et al. 2009; Parker & Ostrander 2005; Turcsan et al. 2011). Ridgebacks were used for hunting lions and other large felids in addition to traditional game. They were sent out in groups of varying size, usually 3-7, tracking down the prey and holding it at bay until the hunter(s) arrived by horse. In order to excel in this, the dogs had to be brave, persistent, clever and confident enough to be able to make its own decisions in tough situations, making this breed willful and independent. As they also had strong guarding abilities, they differed from the traditional breeds by combining hunting and guarding (Costa 2004).

Today, this breed has no practical purpose as a working dog and is mostly held as a companion dog.

2.2 Dog breeds:

All older breeds were originally created on the basis of a need, and individuals were selected for breeding by their talent or ability (Rimbault & Ostrander 2012; Spady & Ostrander 2008; Sutter & Ostrander 2004; Turcsan et al. 2011). Selection was hard, dogs that did not possess the criteria needed for their task did not survive in the meeting with a lion for example, and people had not time or economy to keep hunting dogs that did not succeed in locating game. Dogs were mated to other dogs with similar abilities, and in most cases, dogs were of a uniform type with respect to abilities, but not according to physical appearance. Because of the slow exchange of information and inefficient modes of travel, one could not seek potential breeding partners over long distances, and so in order to manifest traits, one often bred closely related dogs. Inbreeding causes loss of variability by an increase in homozygosity of alleles identical by descent and the dogs would have got more similar looks over time. After generations of inbreeding and so called line breeding, what we today would recognize as breeds was the result of this practice, with different breeds or phenotypically similar dogs often restricted to a particular area or part of a country (Ostrander & Kruglyak 2000).

In modern times, dogs are mostly held as companion dogs, even hunting dogs of various breeds, and hunting does only serve a leisure activity, not as a function critical for survival. This means that selection criteria has moved from necessity to leisure as well, and with the closure of studbooks, dogs are only bred within their breeds, often with strong focus on their appearance rather than their talents or abilities.

2.3 Breeding:

Animal breeding can generally be done in two ways – based upon phenotype only of the animal(s) selected, or based upon genotype on the animal(s) selected, derived from information about relatives and their performance (Bourdon 2000; Vangen et al. 1994), called best linear unbiased prediction or BLUP. The latter method is supreme in getting progress for singular or multiple traits, often by the use of selection indexes for several traits correlated, with estimated breeding values for each animal based on the indexes.

Traditional livestock breeding in Norway have been an enormous success story, with early implementation of breeding values and indexes and breeding for health and soundness simultaneously as for production. This has led to the Norwegian Red becoming an export business for cross breeding with other species in countries with to hard selection pressure on production only, now struggling with issues directly related to high production, and to countries that has been lacking a breeding programme (Vangen et al. 1994).

For companion animals, like horses, dogs and cats, there is no incentive for breeding in one direction (i.e. no economic production goal or common breeding goal), and breeding has been subject to each breeders subjective goal, based upon phenotype rather than genotype, often with a substantial amount of inbreeding (Leroy et al. 2006). Since there has been little focus on performance due to lack of practical need for the dogs particularly, focus has been mostly on appearance and the main goal has been dog shows (Pedersen et al. 2013). In later years, diseases have become very frequent with most breeds being subject to a number of recessive alleles responsible for quite a few autoimmune and other sufferings (Bateson & Sargan 2012; Ekenstedt et al. 2012; Tsai et al. 2012), and more and more genetic tests are available on the market (Leroy & Rognon 2012). In addition to these, hip dysplasia, elbow dysplasia and OCD has had very small decreases in frequencies over the years (Lewis et al. 2010; Malm et al. 2008; Woolliams et al. 2011), even though these diseases has been known and implemented in the breeding programme for decades. Estimated breeding values for hip and elbow dysplasia have been available in Norway, Finland and Denmark for up to 38 breeds for a long time, in Sweden for 5 breeds, in Germany for the German Shepherd, and in the USA for Labrador Retriever. In the United Kingdom, estimated breeding values are anticipated for a range of breeds during 2013 (Lewis et al. 2013).

Meyer et al. (2012) estimated breeding values for a number of behavioral traits in a cohort of Swiss German Sherpherds, ranging from 0,06 for sharpness to 0,20 for both self-confidence and nerve stability. They found a positive genetic trend for all traits over the years, but conclude that the material of dogs tested are pre-selected, because only owners wanting to compete or present their dog as a stud would go through the test.

2.4 Measuring behavior:

Behavior in dogs has been subject of human interest most likely since the start of our coexistence (Turcsan et al. 2011). Wolves or dogs would have been selected based upon traits and behavior important or fascinating to us in order to domesticate this breed. Behavior in animals can be measured in a range of ways, depending on subject of interest, behavioral pattern, whether it is living in controlled environments or maybe in the wild. Examples of these measures are manual registrations, video recording (Palestrini et al. 2010), tracking devices (GPS or similar) for tracing spatial movement, eye movement, (Sutter & Ostrander 2004) among others. For dogs, behavior is either often measured in a direct way, by describing the behavior or scoring the behavior based upon an intensity scale, or the behavior may be described by a subjective measure of a broader personality trait thought to reflect this behavior (Wilsson & Sinn 2012).

These types of registrations may or may not be done in combination with for example a questionnaire where the owner of the animal(s) answers a range of questions related to these measures (Bennett et al. 2012; Mirko et al. 2012; Planta & De Meester 2007; Svartberg 2005; van den Berg et al. 2010; Westgarth et al. 2012). There is also the question of what is the target of research, the behaviors in themself, or the broader traits; i.e. the personality of this particular individual and not only its actions when presented for some kind of stimuli, and also what is the goal of the study/test. For some, it is mainly to assess an individual, either based on problem behavior, or for future work, competition or other. For associations training dogs for the military, police, as guide- or assistance dogs for blind or handicapped, it is important to use the resources on the right dogs, and therefore it will be of importance to be able to at an early stage identify dogs that would fail training later on.

For dogs, there have been many tests developed for measuring traits needed for different types of working dogs, among others military-, police- and guide dogs (Batt et al. 2008; De Meester et al. 2011; Duffy & Serpell 2012; Haverbeke et al. 2009; Leotta et al. 2006; Sinn et al. 2010; Svartberg 2002; Svobodova et al. 2008; Tomkins et al. 2011; Wilsson & Sundgren 1997b). Later years tests have also been developed for those breeds that mainly serve as companion dogs as a tool for breeding and/or for identifying potentially dangerous dogs, like the new Swedish behavior- and personality assessment dog (Blixt et al. 2010).

The DMA measures behaviors rather than traits. The DMA can be grouped into larger personality reflecting dimensions. By factor analysis, Svartberg and Forkman (2002) found five narrow personality dimensions and one broader one that incorporated four of these five dimensions. These five narrow traits were consistent over breed groups, with some exceptions. In two of the breed groups, a sixth trait was found. Later studies have found similar or supporting results in breed specific or combined data (Foyer et al. 2013; Saetre et al. 2006; Strandberg et al. 2005; Svartberg 2005)

2.5 Dog mentality assessment, DMA:

The DMA is a test used as a tool to assess a dog's behavior and mental traits, originally created in 1981 for breeds used for police and military work (Blixt et al. 2007). In 1997, the test was altered, and breeds outside the Swedish Working Dog association were allowed to enter. The last decade, it has proven to be a useful tool for breeders and owners of a wide range of breeds, including the Rhodesian Ridgeback.

The test consists of 10 subtests as shown in table 1, with a total of 33 behavioral variables that are scored by an official describer/observer. Each variable is described by one of five possible intensity scales from 1-5, where 1 is no intensity in the behavior and 5 is very high intensity in the behavior.

Table 1 The 10 subtests with explanation of score intensity

Subtest	Variable	1	2	3	4	5
1. Social contact	1a Greeting	Denies contact – may growl or bite	Avoids contact with evasive behavior	Accepts contact – does not engage or avoid	Takes contact independently or when handler makes contact. Balanced.	Intensive contact behavior. May jump or bark
	1b Cooperation	Will not follow after several attempts of calling	Follows reluctantly. Pulling towards handler or in other direction	Follows the whole walk, neutral	Follows happily. Engaging in person	Follows happily. Shows intensive interest, may jump or bark
	1c Handling	Denies. Growls or may attempt to bite	Avoiding, pulling away or trying to contact handler	Accepts. Neutral	Accepts. Replies with contact	Accepts. Intensive contact behavior
2. Play 1	2a Interest	Will not play	Does not play but shows interest	Plays – slow start but engaging in activity	Plays actively, quick start	Plays very actively, very fast start
	2b Grip	No grip	No grip, sniffing object	Gentle grip	Grips directly with the whole mouth	Grips directly, slashing object
	2c Pull	No bite	Careful bite, lets go, holds but does not pull	Bites – pulling, releases, new bite	Bites with the whole mouth, pulling until person lets go	Direct bite with whole mouth, pulling and snatching
3. Chase	3a1 Following1	Does not start	Starts but stops	Starts or runs slowly. May increase speed. Goes the whole way	Starts with high speed, goal oriented, slowing down at object	Starts directly with high speed. Running past object. May turn back
	3a2 Following2	See above	See above	See above	See above	See above
	3b1 Grabbing1	Ignoring object/does not arrive	No grip, sniffing object	Slow or hesitant grip	Direct grip. Lets go	Direct grip. Holding on for at least 3 sec
	3b2 Grabbing2	See above	See above	See above	See above	See above
4. Passive situation	4 Activity	Inattentive, uninterested, inactive	Inattentive and calm, standing, sitting or laying	Attentive and mainly calm. Some rises in activity.	Attentive but active, strolling around, sniffing	Upset, varying in activities
5. Distance-	5a	Not engaged by figurant.	Control. Some	Interested, following	Interested, attempts to	Very interested. Many attempts

play	Interest	No interest	disruption	figurant with no disruption	start	to start
	5b Aggression	No barking or growling	Some barking and/or growling during the first part	Some barking and/or growling during both parts	Showing aggressive behavior, barking and growling during first part	Showing aggressive behavior, barking and growling during both parts
	5c Curiosity/exploration	Does not approach. Uninterested	Approaches when figurant talks or plays with object	Approaches when figurant is revealed	Approaches hidden figurant slowly or with low body posture.	Approaches hidden figurant directly
	5d Willingness to play	No interest	Does not play but shows interest	Plays –bites, releases, no pulling	Bites directly, may release, pulling	Direct bite with whole mouth, pulling, will not let go
	5e Cooperation	No interest	Engages but stops activity	Activity with active figurant	Active with figurant, interest also with passive figurant	Engages passive figurant to play
6. Sudden app	6a Startle	Freezes, short stop	Crouches and stops	Evasive behavior without looking away	Up to 5 meters of flight	More than 5 meters of flight
	6b Aggression	No threatening behavior	Some threatening behavior	Remaining threatening behavior	Threatening behavior and some attacks	Threatening behavior and attacks that might end in bite
	6c Curiosity/exploration	Approaches when handler takes down coveralls	Approaches when handler sits in front of and speaks to coveralls – calling the dog	Approaches when handler stands beside the coveralls	Approaches when handler has moved half the distance	Approaches directly
	6d Remaining fear	No change of speed or evasive behavior	Going slightly around or subtle change in speed or looking away	Going around or change in speed first passing, less so second time	Going around or change in speed at two passings with same intensity	Showing great or increased fear after all passings
	6e Remaining interest	No interest	Stops, sniffs or looks at coveralls one time	Stops, sniffs or looks at coveralls at least two times	Bites at/play behavior towards coveralls. Losing interest after time	Bites at/play behavior towards coveralls two or more times
7. Metallic noise	7a Startle reaction	Freezes, short stop	Crouches and stops	Evasive behavior without looking away	Up to 5 meters of flight	More than 5 meters of flight
	7b Curiosity/exploration	Does not approach	Approaches when handler sits in front of and speaks to metal – calling the dog	Approaches when handler stands beside the metal	Approaches when handler has moved half the distance	Approaches directly
	7c Remaining avoidance	No change of speed or evasive behavior	Going slightly around or subtle	Going around or change in speed first passing, less so second	Going around or change in speed at two passings with same	Showing great or increased fear after all passings

			change in speed or looking away	time	intensity	
	7d Remaining approach	No interest	Stops, sniffs or looks at metal one time	Stops, sniffs or looks at metal at least two times	Bites at/play behavior towards metal. Losing interest after time	Bites at/play behavior towards metal two or more times
8. Ghosts	8a Aggression	No threatening behavior	Some threatening behavior	Remaining threatening behavior	Threatening behavior and some attacks	Threatening behavior and several attacks
	8b Attention	Single control, then no interest/avoiding situation	Looking at the ghosts from time to time	Controlling/handling the ghosts. Long interruptions	Controlling/handling both ghosts. Shorter interruptions	Controlling/handling both ghosts continuously
	8c Fear	In front of or beside handler	In front of or beside handler. Some distance control	Mainly in front of or beside handler. Varying between flight and control	Behind handler most of the time. Varying between flight and control	Flight more than length of leash. May seek support from the audience or leave the scene
	8d Curiosity/exploration	Approaches when handler has removed figurants disguise	Approaches when handler talks to figurant/calling the dog	Approaches when handler is beside ghost	Approaches when handler has moved half the distance	Approaches directly
	8e Contact	Denies or avoids contact with evasive behavior	Accepts contact – does not engage or avoid	Takes contact when figurant invites	Takes contact independently. Balanced.	Intensive contact behavior. May jump or bark
9. Play 2	9a Interest	Will not play	Does not play but shows interest	Plays – slow start but engaging in activity	Plays actively, quick start	Plays very actively, very fast start
	9b Grip	No grip	No grip, sniffing object	Gentle grip	Grips directly with the whole mouth	Grips directly, slashing object
10. Gunshot	10 Avoidance	Shows no avoidance behavior. Quick control and then unaffected.	Controlling first shot then unaffected. Short break in activity	Decreasing controls/interest in shooter/goes back to activity or passivity	Stops activity/locking against shooter. Cannot engage in activity	Remaining stress after several shots. Aborts subtest after flight tendencies/gunshot omitted

For each variable, the preferred score may be high, low or even intermediate, and desired scores differ from breed top breed depending upon the original function and the breed standard of the breed. All dogs pass the test irrespective of scores, unless owner/handler or describer chooses to terminate the test at any point. Dogs that have terminated one test may be tested again once more, unless it has been terminated because of aggressive behavior.

The test is carried out outdoors by one of the SWDA’s local clubs, and officials are trained and certified by the SWDA. In addition to the describer, there is one test-leader (TL), who is in charge of the practicalities of the test and who is the one who handles the dog during the contact and play elements. For the other elements, functionaries/figurants are used; these remain hidden from the dog until the start of the subtest or the whole time as in the gunshot test.

The preset trail for the different subtests is built up in advance at different stations with natural surroundings, preferably forest, so that the situation seems like a normal walk for the dog. The 10 subtests are carried out in a standardized order; social contact, play 1, chase, passive situation, distance-play, sudden appearance, metallic noise, ghosts, play 2, and gunshot.

In social contact, the dog's reaction to a stranger is tested and described trough greeting, cooperation (TL takes the dog for a short walk without the owner) and physical handling. Play 1 and 2 are alike, where the dog's interest in playing with a stranger is assessed, and also its intensity in grabbing and pulling on the item (pulling only in play 1). The chase is a rug, fastened to a wire/rope on a course around 10 small wheels, making the object move away from the dog in zigzag movements. The dog's interest in following and grabbing the item is scored, and the whole test is carried out once more (the dog is not allowed to watch when the item is laid out again). During the passive situation, all people present remains passive and still for three minutes, and the dog's response to this situation is scored. In the distance-play subtest, an unfamiliar person in a hooded cape moves back and forth on a line at a distance, suddenly crouching down two times and after that taking of the hood and throwing the same object as in play up for the dog to see. The person then hides, and removes the cape without the dog seeing, and then the dog's approach (or not approaching) and willingness to play and cooperation with the active and passive person is scored. In sudden appearance, dog and leader are walking along a path when a coverall attached to the ground and to a plank with a pulley and a rope, so that a functionary may stand in the background and pull the coverall into a "standing" position before the dog. The dogs startle reaction, aggressive reaction, exploration/curiosity, remaining fear/avoidance behavior and remaining interest is scored. The metallic noise is a large metal chain or similar metal object, dragged on top of a corrugated iron plate just beside the trail where the dog and leader are walking, parallel to them. Scored are the dogs startle reaction, exploration/curiosity, remaining fear/avoidance and remaining interest. At the subtest "ghosts", two functionaries dressed in white sheets with holes for eyes are approaching the dog and handler slowly from a distance, one ghost from each corner (the dog and the two ghosts making a triangle) and only one ghost moving at a time. Aggression, attention, fear, curiosity/exploration and contact are scored in this subtest. The last subtest, the gunshot, is conducted after play 2, and three gunshots are fired by a hidden functionary, two shots when dog and handler is playing and two shots when they are standing passively. The dog's reaction in the form of flight reaction is scored.

3 MATERIAL AND METHOD:

3.1 Data:

The dataset was provided from SKK, one raw file containing information about all Ridgebacks registered with breed code, type, registration number, time of test, class, type of animal at hunting test, placement, score, judge 1 and judge 2, plus the result of any type of competition (hunting, herding, blood tracking, agility, obedience, show, DMA, other mentality tests etc). One file contained pedigree information with breed code, registration number, name, sex, any type of champion title, birthdate, breed specific information, fur quality, size, whether or not the dog is legible for breeding, testicle status, registration number of father and mother and color of the dog (n=10155).

The pedigree file information was reduced to registration number, name, sex, birth date, registration number of father and mother and corrected with respect to names. For analysis of variance components factor analysis and prediction of breeding values, the pedigree file was further reduced to include only dogs with test results and their ancestors (n=3569).

For all analyzes, only dogs with complete DMA were included, excluding dogs with no DMA and with DMA aborted (41 dogs aborted by judge, 35 by owner and 20 unknown) or where gunshot or exploration has been omitted (32 and 10 dogs) (total n=138).

Data used in this study consisted of behavior test results of 2022 dogs from June 1997 to Oct 2012. Percentage of male and female dogs with test results were 50,4 and 49,6 respectively, and average age at test was 760,4 days ±352,3 days. The youngest dog was 365 days old exactly, while the oldest dog was 3815 days old, but over 60% of the tested dogs were below two years of age and only 11% over 3 years of age as shown in figure 1. Here the number of dogs within the different age categories used in further analysis are shown; dogs between 12 and 18 months is in category 1, 18-24 in category 2, 24-30 in category 3, 30-36 in category 4 and over 36 months in category 5.

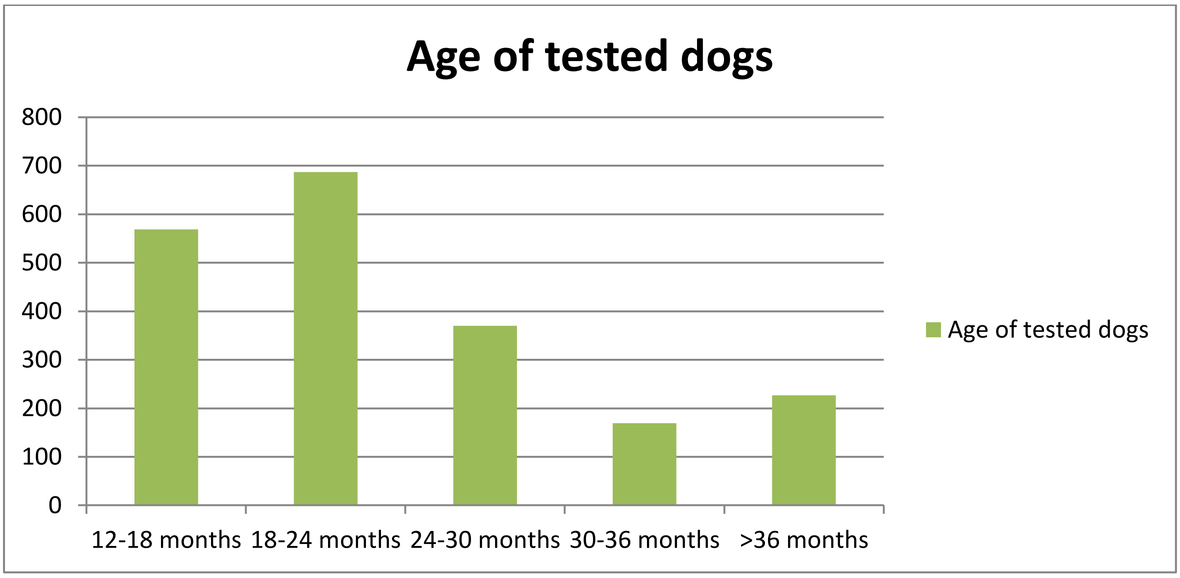


Figure 1 Number of tested dogs in each age category

Of the 2022 dogs, 1954 dogs were inbred, which gave an average inbreeding coefficient of 1.70%. Within the inbred population, average inbreeding coefficient was 2.59%. The dogs were born in 604 litters, tested by 161 judges at 529 separate occasions. Figure 34 shows the distribution of dogs tested each year, with an average of 126,4 dogs ±56,9 dogs. The highest number of dogs tested was in 2009, with 227 dogs, and there was a general increase in number of dogs tested yearly up to this point. The low number of dogs tested in 2012 may be explained by the fact that a new type of mentality test has been available from this year on. In addition to this, there may be a delay in reporting the results from the various local clubs, so that there may be some tests done during 2012 where the results were not available at the time of the data collection.

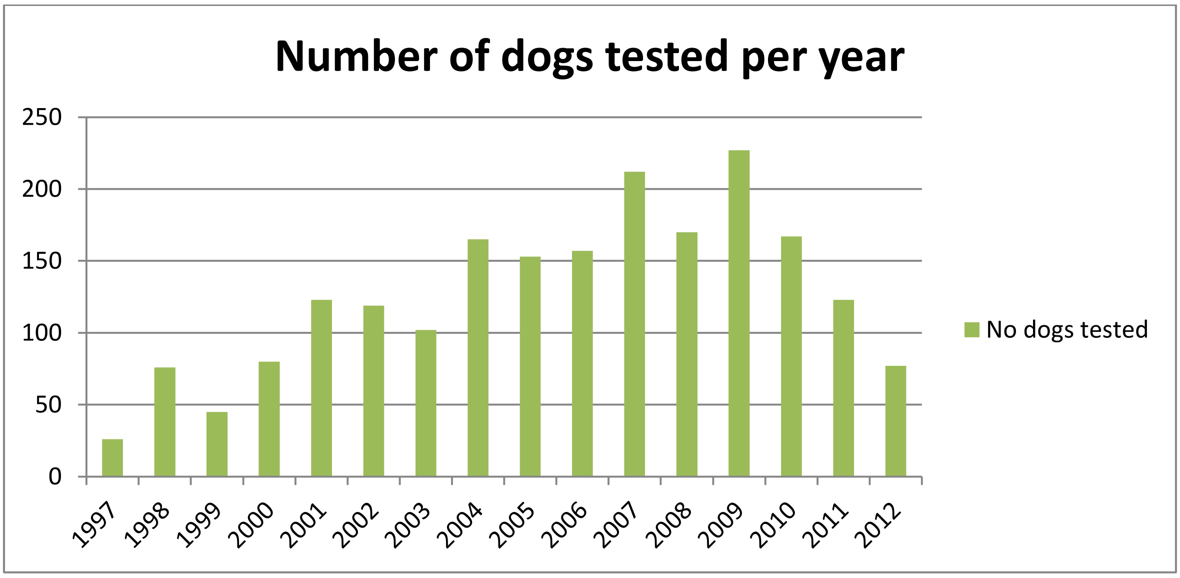


Figure2 Number of dogs tested yearly

3.2 Frequencies:

Figures 3 to 33 show the distribution of scores in each of the 33 variables.

As shown, not all variables have normally distributed scores, and some of them have very skewed distributions, where some scores may not be in use (figures 10, 13, 14, 15, 16, 21, 24, 25). This distribution varies between breeds and data material and is not consistent for the test as such, but can be seen as a guideline of how well the test scores are suited this particular dataset.

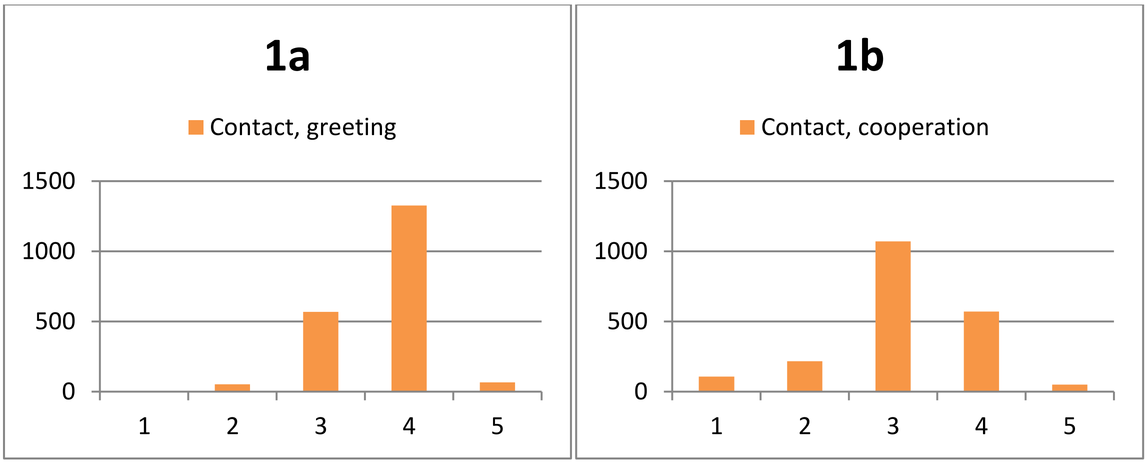
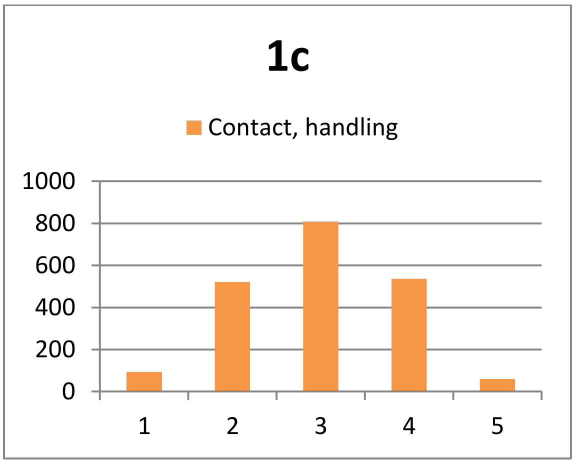


Figure 3 and 4 Distribution of scores in elements 1a and 1b



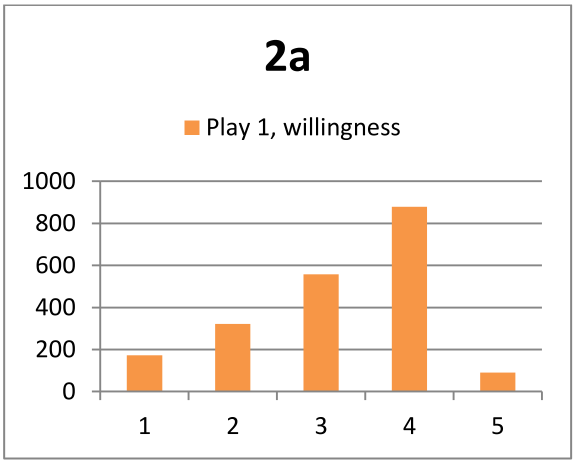
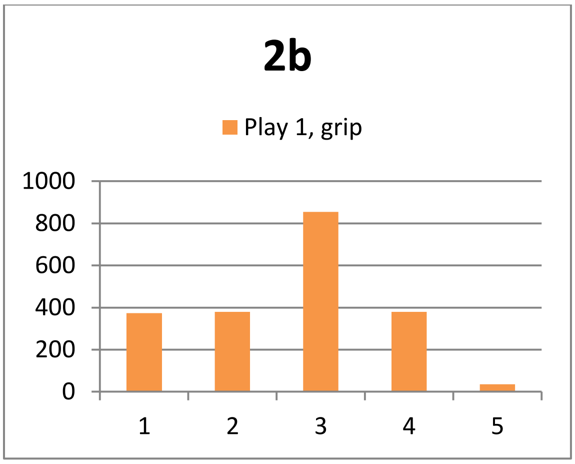


Figure 5 and 6 Distribution of scores in elements 1c and 2a



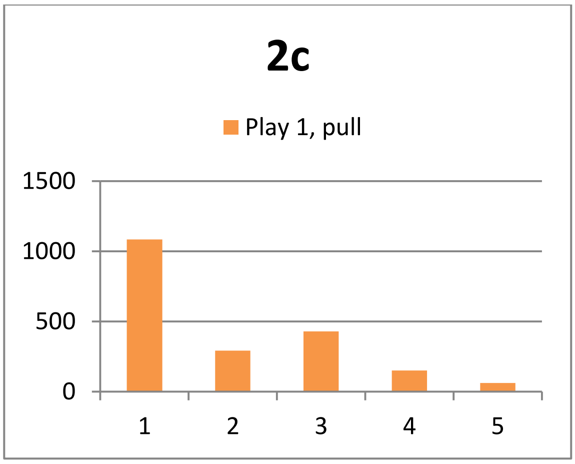
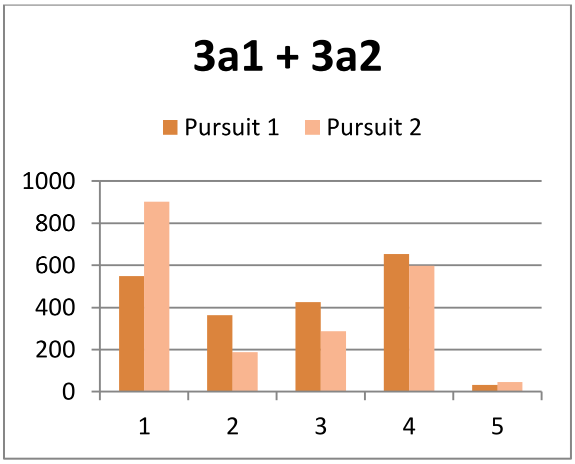


Figure 7 and 8 Distribution of scores in elements 2b and 2c



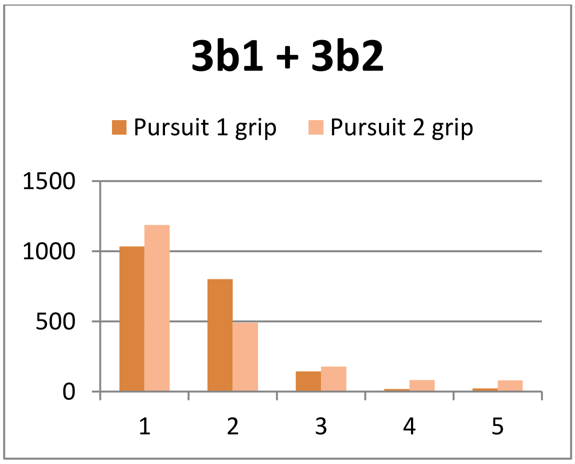
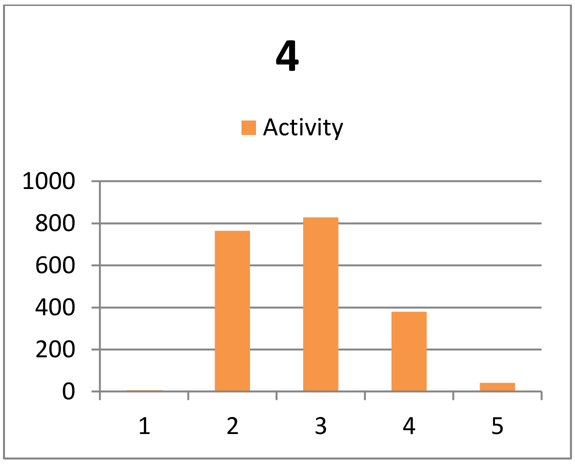


Figure 9 and 10 Distribution of scores in elements 3a 1 and 2 and 3b 1 and 2



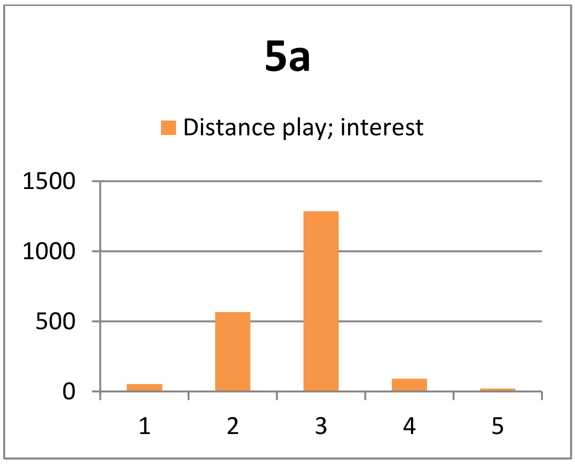
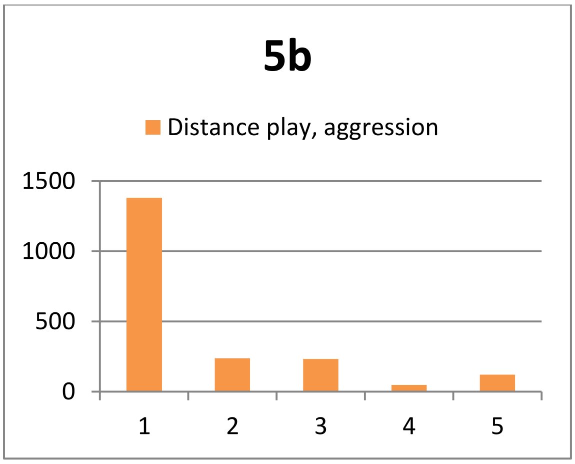


Figure 11 and 12 Distribution of scores in elements 4 and 5a



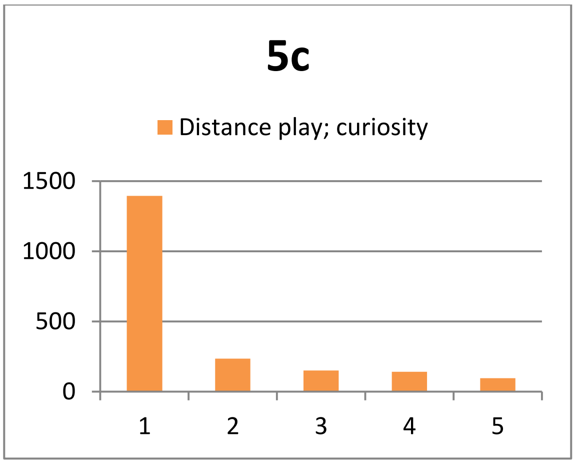
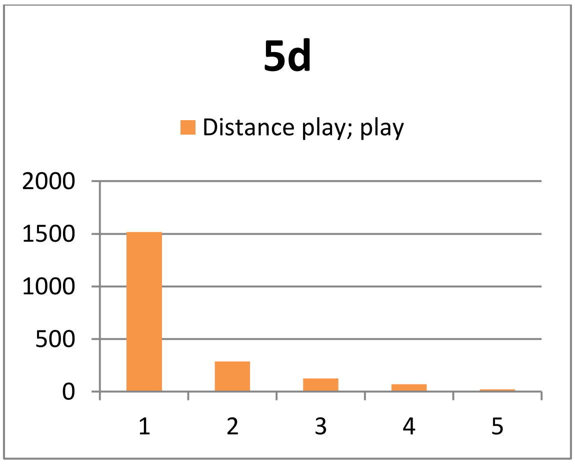


Figure 13 and 14 Distribution of scores in elements 5b and 5c



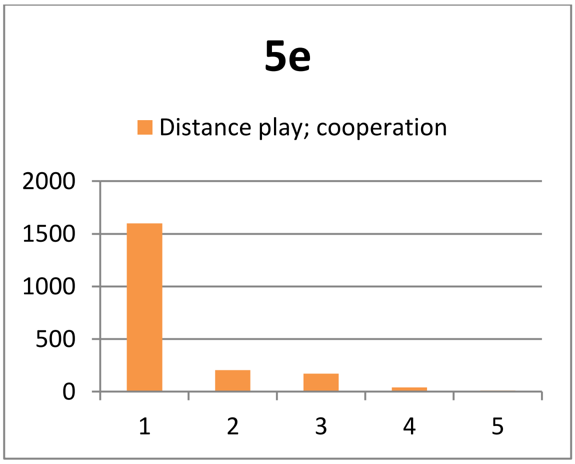
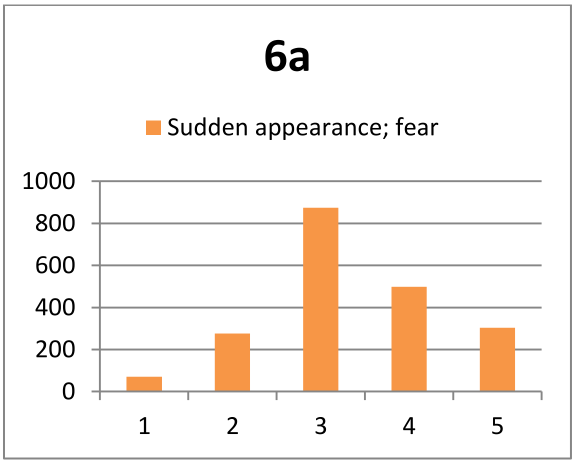


Figure 15 and 16 Distribution of scores in elements 5d and 5e



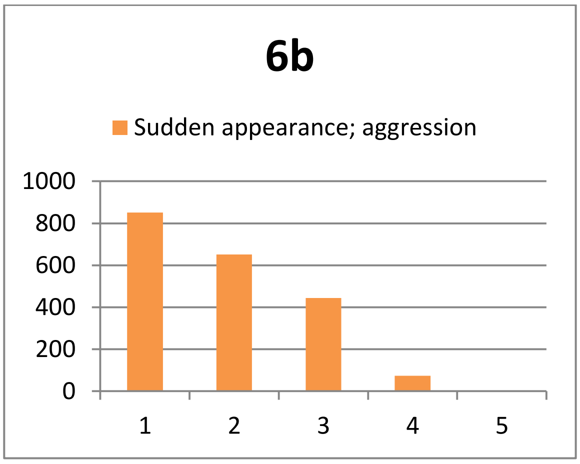
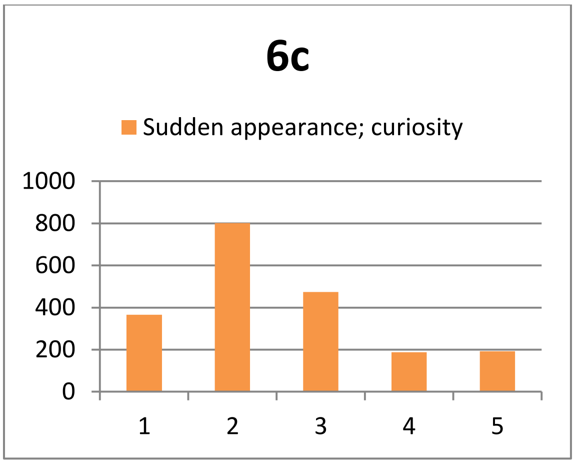


Figure 17 and 18 Distribution of scores in elements 6a and 6b



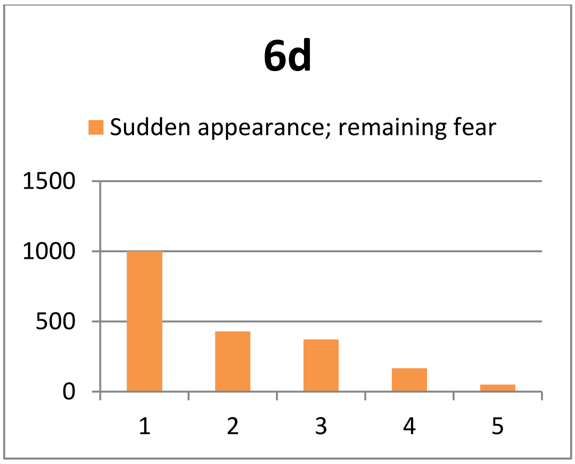
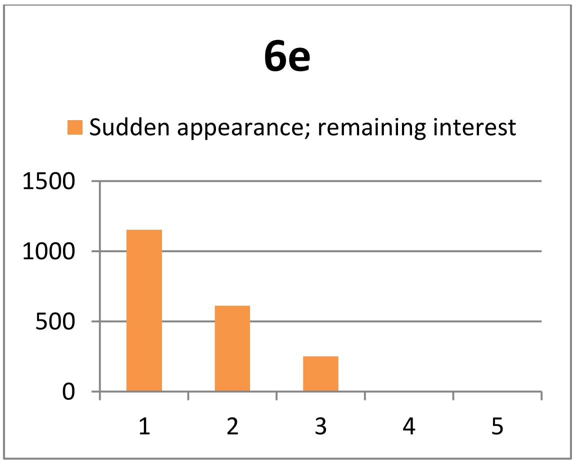


Figure 19 and 20 Distribution of scores in elements 6c and 6d



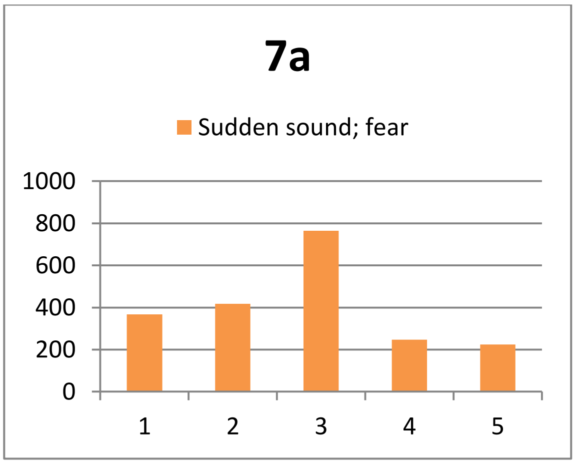
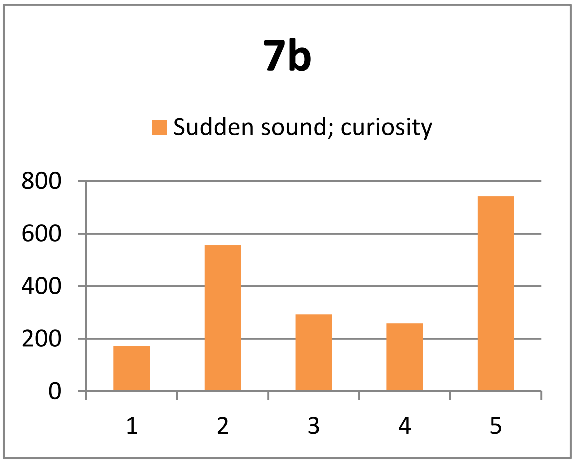


Figure 21 and 22 Distribution of scores in elements 6e and 7a



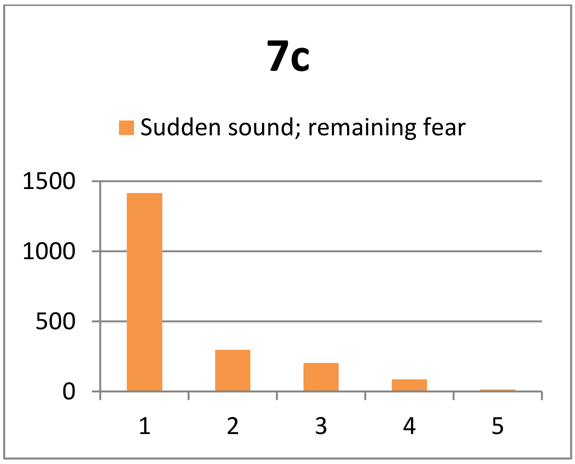
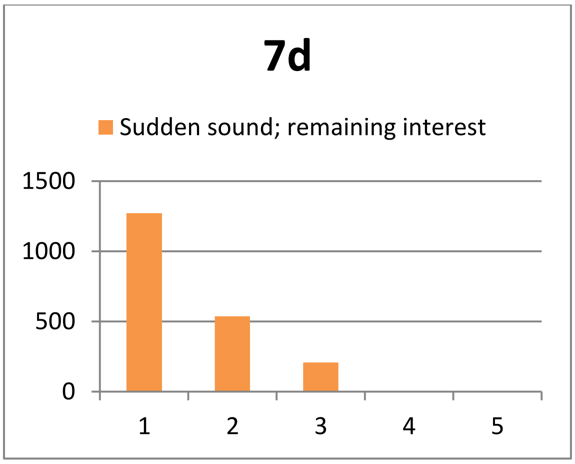


Figure 23 and 24 Distribution of scores in elements 7b and 7c



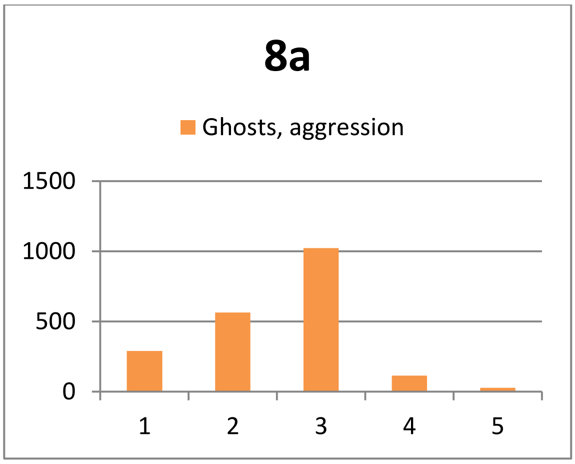
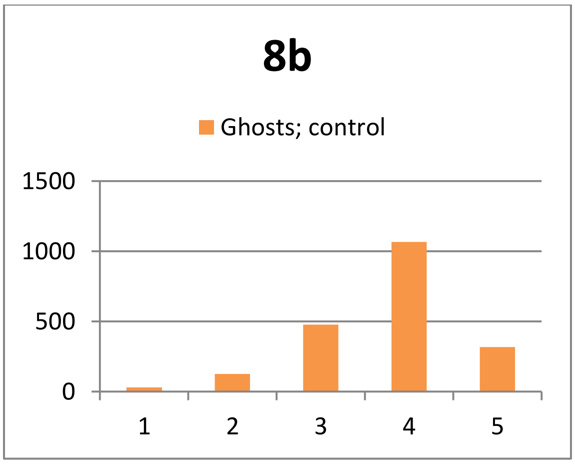


Figure 25 and 26 Distribution of scores in elements 7d and 8a



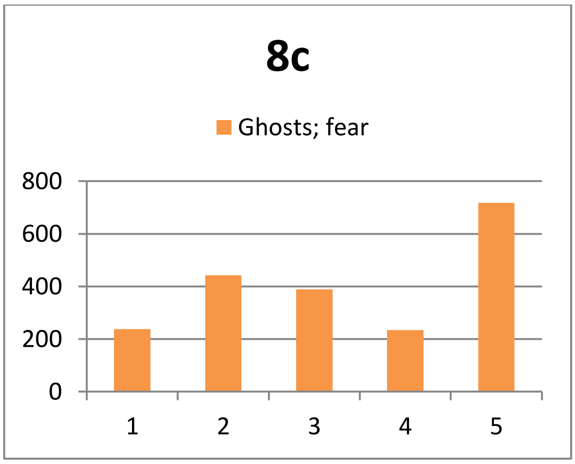
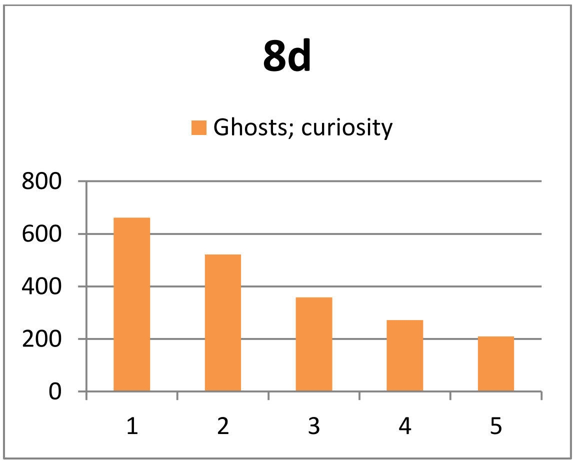


Figure 27 and 28 Distribution of scores in elements 8b and 8c



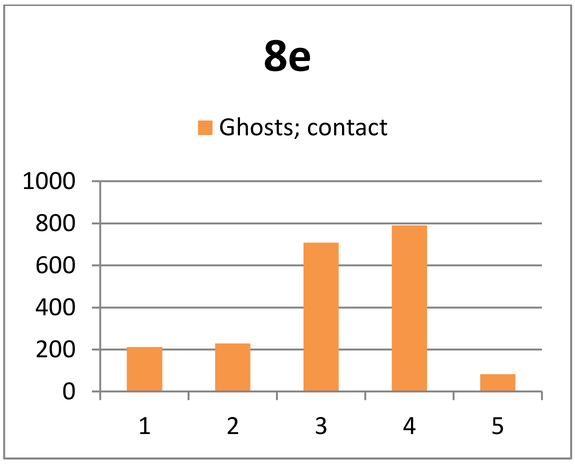
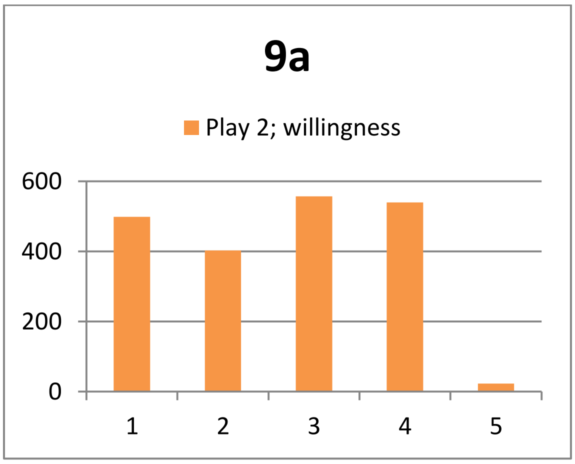


Figure 29 and 30 Distribution of scores in elements 8d and 8e



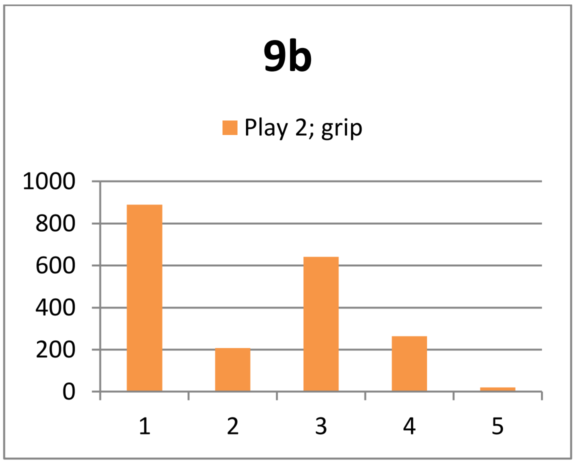


Figure 31 and 32 Distribution of scores in elements 9a and 9b

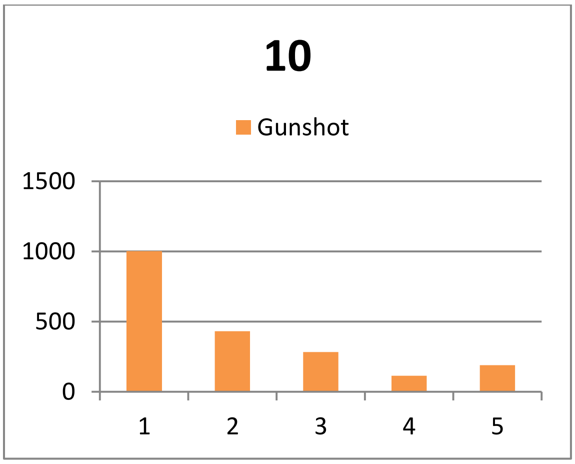


Figure 33 Distribution of scores in element 10

The average Ridgeback's scores on the DMA are showed in figure 34.

As shown, in this sample, the average score on the contact elements are between 3 and 4, play 1 interest is just above 3, while the remaining play and chase scores are below 3. Sudden appearance startle, metallic noise exploration, ghosts attention, fear and contact are all above 3, while all other scores average below 3. The standard deviations range from 0,58 to 1,45.

The overall Ridgeback in this sample is a friendly dog without overwhelming greeting, accepts handling but on the shy side (average on 1c below 3,0). It plays a bit, but does not bite or pull. It is moderately interested in chasing the rug, but does not grab this object either. It is calm during the passivity, moderately interested in the distance play person with few aggressive signals but does not approach the person. It gets scared when the overall appears in subtest 6 but has few aggressive signals and is mildly curios/explores it with help. It has some remaining fear that diminishes. In the metallic noise, the average dog is not very scared, explores the item with some help and has very little remaining fear or interest thereafter. It tries some aggressive signals when the ghosts appear, controlling their movements from beside or behind the handler, not sure whether to escape or stay. It needs help to explore the ghosts and when the figurant invites it replies with contact behavior. It is less interested in playing the second time and has a control reaction to the first shot but is then unaffected.

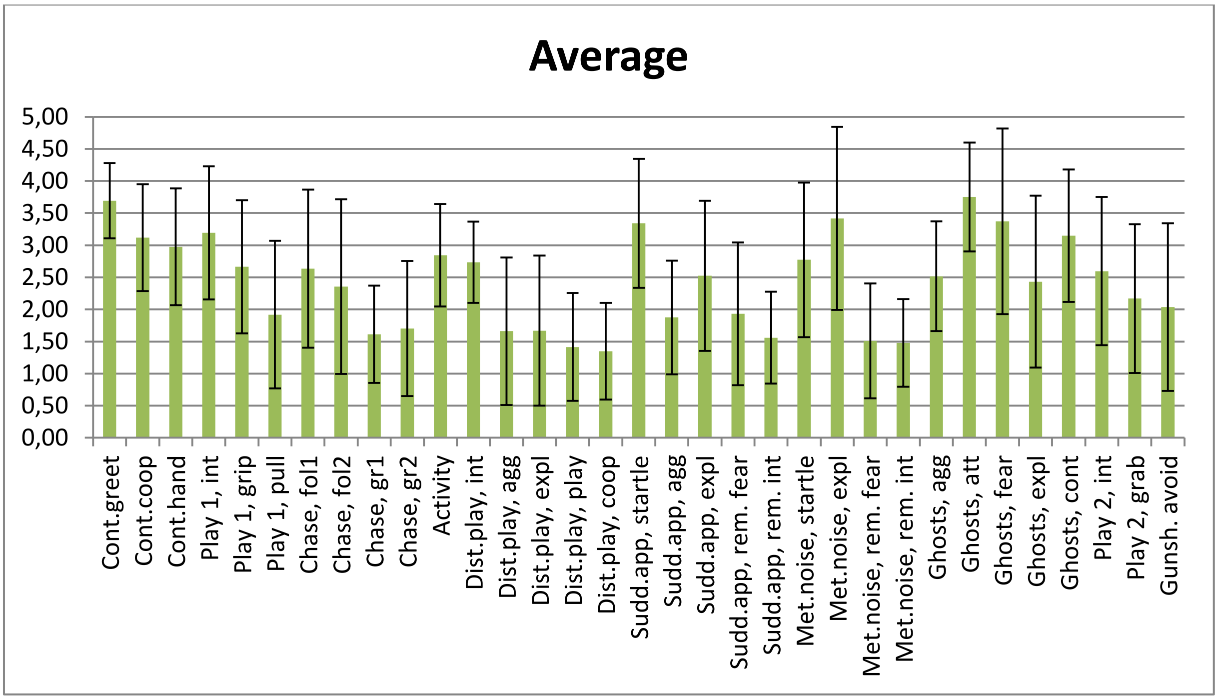


Figure 34 The average scores and standard errors for each variable

3.3 Statistics:

For descriptive statistics, Excel and SAS were used, while the analyses of the data were performed in either SAS (factor analysis and preliminary analysis) or Wombat (variance components and heritability). Breeding values were predicted using Matlab.

For the preliminary analysis and for the factor analysis, dogs with two test results were included with both results (total n=2022, males 1020, females 1002), but for the heritability analysis in Wombat, only the first recorded test of these three animals were used for analysis (total n=2019, males 1017, females 1002).

In a preliminary factor analysis, raw phenotype data was analyzed both with the prinit/iterated principal factor analysis and the factor principal component analysis, and the results were considered with both unrotated and varimax rotation. After having chosen an appropriate model, the analysis was done again, with scores corrected for fixed effects. The second analysis is therefore on the variation that remains for random effects and the residual.

Criteria for selecting number of factors were eigenvalues>1, the factors explaining as many of the variables as possible without selecting all ten subtests as factors, high (or respective low) loadings of each variable should be on one trait/factor only and loadings were considered high when >0,4 or <-0,4.

For the six traits used when predicting breeding values, standardized values were used by subtracting the mean score from each dog's score on each variable and dividing by the standard deviation, so that different means and skewed use of the behavior scores would not influence the loadings of the variables in the traits.

3.4 Model:

Based on previous studies (Meyer et al. 2012; Ruefenacht et al. 2002; Saetre et al. 2006; Wilsson & Sundgren 1997a; Wilsson & Sundgren 1997b) the effects of sex, litter, age at testing, specific test situation (personnel, time and place) judge, month and year of testing were examined.

Since 12 months is the lower limit for testing and since dogs are assumed to be mature and not very much influenced by further experiences after three years of age, age at testing was separated into five age classes, up to 18 months, 18-24 months, 24-30 months, 30-36 months and over 36 months.

All the three winter months in this dataset consisted of very few individuals tested (1, 2 and 2), thus, by merging months into categories, this would not have made the categories more similar in size. It was therefore decided to keep all months separated.

Because of the very high number of different judges (161) and since many of them only had tested one or very few individuals, the effect of judge was decided as random.

The random litter effect was included in the model, together with random effect of specific test situation, which is taking into account the specific details around the test situation, like personnel, other dogs, weather etc.

The final model used for estimating variance components and heritabilities was a linear mixed model;

[1] $Y_{ijklm} = s_i + ty_j + tm_k + ac_l + a_m + e_{ijklm}$

where

- Y_{ijklm} is the score of the behavioral trait of dog m,
- s_i is the fixed effect of sex (i=1, 2),
- ty_j is the fixed effect of test year (j=1997-2012),
- tm_k is the fixed effect of test month (k=1-12),
- ac_l is the fixed effect of age class (l=1, 2, 3, 4,5),
- a_m is the additive genetic effect of the animal with distribution $\sim N(0, A\sigma^2_a)$
- and e_{ijklm} is the residual $\sim N(0, I\sigma^2_e)$.
- A is the numerator relationship matrix and I is the identity matrix of appropriate size

In matrix form, used for predicting breeding values, the general model is;

[2] $$y = X\beta + Zu + \epsilon$$

where

- y is a vector of observations
- β is a vector of fixed effects
- u is a vector of random effects with mean E(u)=0 and variance-covariance matrix var(u)=G
- ϵ is a vector of random error terms with meanE(ϵ)=0 and variance var(ϵ)=R
- X and Z are matrices relating the observations y to β and u

Table 2 Significance of the fixed effects on each variable, variables presented in order of the test

Variable	Sex	Test year	Test month	Age category
Contact, greeting	**	ns	ns	***
Contact, cooperation	***	ns	ns	***
Contact, handling	***	ns	ns	**
Play 1, interest	***	ns	*	***
Play 1, grip	***	ns	ns	***
Play 1, pull	***	*	ns	***
Chase, following1	ns	*	***	***
Chase, grabbing1	ns	*	*	***
Chase, following2	*	**	ns	***
Chase, grabbing2	**	*	ns	***
Activity	***	ns	ns	***
Distance play, interest	ns	ns	ns	*
Distance play, aggression	***	ns	ns	ns
Distance play, exploration	***	**	*	**
Distance play, play	***	**	***	***
Distance play, cooperation	***	**	**	***
Sudden app, startle	***	ns	ns	***
Sudden app, aggression	ns	ns	ns	ns
Sudden app, exploration	ns	ns	ns	***
Sudden app, remaining fear	*	ns	**	ns
Sudden app, remaining interest	ns	*	ns	ns
Metallic noise, startle reaction	ns	ns	ns	ns
Metallic noise, exploration	ns	ns	**	ns
Metallic noise, remaining fear	***	ns	***	ns
Metallic noise, remaining interest	*	*	ns	***
Ghosts, aggression	ns	***	ns	ns
Ghosts, attention	ns	ns	ns	ns
Ghosts, fear	***	ns	ns	***
Ghosts, exploration	**	*	ns	*
Ghosts, contact	ns	ns	ns	ns
Play 2, interest	***	*	***	***
Play 2, grabbing	***	**	**	***
Gunshot, avoidance	ns	ns	*	ns
*** P<0,001, **P<0,01, *P<0,05				

4 RESULTS:

4.1 Fixed effects:

Table 2 gives the fixed effects result on each variable, as estimated with the univariate mixed model [1]. Sex and age category had significant effects on approximately 60% of the variables, while test year and month had effect on less than half of the variables. For four variables, sudden appearance aggression, metallic noise, startle reaction, ghost attention and contact, no effects were significant. For the distance play and the play 2 subtests, all effects were significant.

4.2 Factor analysis:

For the 33 variables, 10 factors were suggested retained by the eigenvalue criterion. This corresponds to the 10 subtests, but to further analyze any pattern between the variables, numbers of factors from 3-8 was retained trough the nfact criterion in SAS. As the criteria of selecting the best fitting number of factors, factor loadings were used, where any variable should only load high on preferably one factor (above or below 0,4 is considered high loadings), and the model should explain as many variables as possible. In addition to this, variance explained by each factor was considered.

Table 3 shows the results of the factor analysis with six factors, with the raw data (phenotypic data). In table 4 below, the same results, with the factor analysis done with the residuals can be seen. The numbers in bold represent the loadings that contribute to each of the factors. In both cases, only four variables remained unexplained; activity, remaining interest of the sudden appearance and the metallic noise, and the gunshot test. For the raw data analysis, factor loadings were relatively high, most loadings above 0,6. Only three variables loaded fairly high on a second factor; ghosts fear, exploration and contact loaded with 0,42 on the sociability factor, 0,5 and -0,4 on the fear/curiosity factor, respectively and over 0,3/-0,3 on their second factor. Ghosts exploration even loaded with 0,3 on a third factor, but this was in contrast to the negative loadings on the other two factors a positive loading on distance play. As can be seen in table 4, ghosts fear jumps from the sociable factor to the fear/exploration factor when the residual data are analyzed. Apart from this, differences are small between the two analyzes, with loadings very similar and variance explained by each factor in the same range (1,81/1,87 for the sixth factor with residual/raw data to 3,29/3,49 for the first factor with residual/raw data).

Table 3 Factor analysis based on raw phenotypic data, variables presented in the order of the test. Numbers in bold are loadings for the corresponding variable on the factor.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
	Play	Fear/exploration	Chase/hunt	Distance play	Defense	Sociable
Contact, greeting	0,21	-0,10	0,00	0,07	0,02	**0,58**
Contact, cooperation	0,22	-0,06	-0,03	0,16	-0,02	**0,63**
Contact, handling	0,11	-0,06	-0,07	0,19	-0,04	**0,63**
Play 1, interest	**0,76**	-0,05	0,11	0,12	0,07	0,25
Play 1, grip	**0,80**	-0,01	0,16	0,03	0,02	0,16
Play 1, pull	**0,68**	-0,02	0,12	0,23	0,04	0,18
Chase, following1	0,13	-0,09	**0,79**	0,12	0,03	-0,05
Chase, grabbing1	0,17	-0,04	**0,81**	0,08	0,01	0,01
Chase, following2	0,11	-0,12	**0,79**	0,08	0,02	-0,01
Chase, grabbing2	0,18	-0,09	**0,77**	0,03	0,00	0,03
Activity	0,15	0,09	0,01	0,03	0,14	0,07
Distance play, interest	0,06	0,07	0,08	0,11	**0,45**	0,10
Distance play, aggression	-0,03	0,08	-0,10	-0,16	**0,61**	0,03
Distance play, exploration	0,06	-0,10	0,14	**0,78**	-0,01	0,11
Distance play, play	0,20	-0,01	0,13	**0,84**	0,03	0,18
Distance play, coop	0,17	-0,01	0,11	**0,82**	0,02	0,19
Sudden app, startle	0,04	**0,59**	0,04	-0,14	0,09	0,10
Sudden app, aggression	0,06	-0,04	-0,05	0,01	**0,66**	-0,11
Sudden app, exploration	0,00	**-0,66**	0,08	0,05	0,00	-0,09
Sudden app, rem. fear	-0,01	**0,67**	-0,10	-0,01	0,03	-0,18
Sudden app, rem. interest	0,00	-0,02	-0,01	0,09	0,19	0,15
Metallic noise, startle	-0,01	**0,65**	-0,05	-0,01	-0,07	-0,06
Metallic noise, explor	0,12	**-0,60**	0,19	-0,08	0,11	0,00
Metallic noise, rem. fear	-0,06	**0,61**	-0,10	0,13	-0,02	-0,25
Metallic noise, rem. int	0,15	-0,01	0,02	0,00	0,17	0,03
Ghosts, aggression	-0,01	-0,05	0,03	-0,08	**0,76**	-0,04
Ghosts, attention	0,00	-0,13	0,07	0,03	**0,56**	-0,08
Ghosts, fear	-0,06	0,38	0,16	-0,25	0,10	**0,42**
Ghosts, exploration	0,13	**-0,50**	-0,07	0,35	-0,08	-0,33
Ghosts, contact	0,17	**-0,40**	-0,11	0,32	0,11	-0,11
Play 2, interest	**0,85**	-0,08	0,15	0,12	0,00	-0,02
Play 2, grabbing	**0,82**	-0,08	0,16	0,05	0,01	-0,03
Gunshot, avoidance	0,09	0,34	-0,05	-0,02	-0,01	-0,24
Variance explained	3,49	3,19	2,80	2,55	2,04	1,87

Table 4 Factor analysis based on residual data, variables presented in the order of the test. Numbers in bold are loadings for the corresponding variable on the factor.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
	Play	Fear/exploration	Chase/hunt	Distance play	Defense	Sociable
Contact, greeting	0,16	-0,07	0,01	0,05	0,02	**0,60**
Contact, cooperation	0,17	-0,05	-0,02	0,12	-0,03	**0,67**
Contact, handling	0,08	-0,05	-0,06	0,15	-0,04	**0,68**
Play 1, interest	**0,75**	-0,04	0,09	0,10	0,07	0,26
Play 1, grip	**0,79**	0,01	0,14	0,02	0,02	0,15
Play 1, pull	**0,66**	-0,01	0,11	0,20	0,05	0,18
Chase, following1	0,11	-0,08	**0,79**	0,10	0,02	-0,05
Chase, grabbing1	0,15	-0,02	**0,81**	0,07	0,00	0,00
Chase, following2	0,09	-0,11	**0,79**	0,06	0,01	-0,01
Chase, grabbing2	0,16	-0,09	**0,78**	0,01	-0,01	0,03
Activity	0,09	0,11	0,00	-0,01	0,14	0,08
Distance play, interest	0,05	0,08	0,06	0,13	**0,47**	0,07
Distance play, aggression	-0,01	0,08	-0,09	-0,16	**0,61**	0,05
Distance play, exploration	0,04	-0,10	0,12	**0,78**	-0,01	0,09
Distance play, play	0,17	-0,02	0,10	**0,85**	0,02	0,15
Distance play, coop	0,13	-0,01	0,08	**0,84**	0,01	0,16
Sudden app, startle	0,01	**0,58**	0,03	-0,12	0,07	0,06
Sudden app, aggression	0,08	-0,06	-0,05	-0,01	**0,65**	-0,08
Sudden app, exploration	0,02	**-0,66**	0,09	0,04	0,00	-0,06
Sudden app, rem. fear	0,00	**0,66**	-0,09	0,02	0,01	-0,18
Sudden app, rem. interest	-0,01	-0,03	0,00	0,08	0,14	0,12
Metallic noise, startle	-0,03	**0,64**	-0,05	0,00	-0,07	-0,07
Metallic noise, explor	0,11	**-0,60**	0,18	-0,08	0,10	-0,01
Metallic noise, rem. fear	-0,03	**0,59**	-0,07	0,14	-0,04	-0,20
Metallic noise, rem. int	0,14	-0,04	0,01	0,00	0,12	0,02
Ghosts, aggression	0,00	-0,05	0,05	-0,08	**0,76**	-0,03
Ghosts, attention	-0,01	-0,13	0,06	0,05	**0,58**	-0,10
Ghosts, fear	-0,08	**0,41**	0,15	-0,21	0,09	0,34
Ghosts, exploration	0,15	**-0,52**	-0,07	0,31	-0,08	-0,25
Ghosts, contact	0,16	**-0,42**	-0,10	0,30	0,08	-0,04
Play 2, interest	**0,85**	-0,07	0,12	0,10	-0,01	-0,05
Play 2, grabbing	**0,81**	-0,06	0,13	0,03	0,00	-0,06
Gunshot, avoidance	0,11	0,34	-0,05	-0,02	-0,01	-0,20
Variance explained	3,29	3,16	2,73	2,48	2,04	1,81

4.3 Heritabilities and random effects:

For the estimation of heritabilities, the factor result of the residual data was used, with the variable ghosts, contact loading on the fear/exploration factor.

Table 5 shows the amount of variation due to the random effects of litter (σ^2L), specific test situation (σ^2T), judge (σ^2J), genetic effect ($\sigma2a$) and the remaining residual ($\sigma2e$). Heritabilites were estimated both with $h^2 = \sigma2a/(\sigma2a+\sigma2e)$ and with $h^2\ W = \sigma2a/(\sigma2a+\sigma2e+\sigma^2L+ \sigma^2T+ \sigma^2J)$. Standard errors are given for h^2 W (SE W). Significant effects are highlighted in yellow. The heritabilities ranged from 0 to 0,34 (h^2) and 0 to 0,31 (h^2 W). In most cases, heritabilities for the six traits were larger than for the separate variables, and in the cases where they were not (distance play, defense, sociable), they were larger than the average of the separate variables. The two remaining interest variables showed no significant heritabilities, and no heritability at all for the metallic sound remaining interest variable. The effect of litter was only significant on one variable and one trait (distance play aggression and defense), while the effect of specific test situation and judge was significant on over half of the variables/traits. The effects ranged from 0 to 17 percent.

Table 5 Heritabilities and random effects with standard errors. Variables are presented in order from the six traits, the traits are shown in black. The leftover variables are shown in blue.

Variable	σ2e	SE	σ2a	SE	h^2	h^2W	SE W	σ^2L	SE	σ^2T	SE	σ^2J	SE
Play 1, int	0,78	0,04	0,11	0,04	0,13	0,12	0,04	0,02	0,02	0,04	0,02	0,03	0,02
Play 1, grip	0,79	0,04	0,12	0,04	0,13	0,12	0,04	0,00	0,02	0,06	0,02	0,01	0,01
Play 1, pull	1,03	0,04	0,06	0,04	0,05	0,05	0,03	0,06	0,03	0,03	0,02	0,03	0,02
Play 2, int	0,93	0,04	0,10	0,05	0,09	0,08	0,04	0,04	0,03	0,07	0,03	0,02	0,01
Play 2, grab	0,98	0,04	0,10	0,05	0,09	0,08	0,04	0,04	0,03	0,08	0,03	0,00	0,01
Factor 1 - Play	0,44	0,02	0,08	0,03	0,16	0,14	0,04	0,02	0,01	0,04	0,01	0,00	0,01
Sudd.app, startle	0,68	0,04	0,21	0,05	0,24	0,22	0,05	0,01	0,02	0,06	0,02	0,01	0,01
Sudd.app, rem. fear	0,93	0,04	0,12	0,05	0,11	0,09	0,04	0,00	0,03	0,06	0,03	0,14	0,04
Met.noise, startle	1,00	0,05	0,22	0,07	0,18	0,15	0,04	0,02	0,04	0,11	0,04	0,10	0,04
Met.noise, rem. fear	0,55	0,03	0,06	0,03	0,10	0,08	0,04	0,03	0,02	0,04	0,02	0,11	0,03
Ghosts, fear	1,43	0,08	0,32	0,10	0,19	0,16	0,04	0,05	0,05	0,12	0,05	0,16	0,06
Sudd.app, expl	0,99	0,05	0,28	0,07	0,22	0,21	0,05	0,00	0,03	0,07	0,03	0,04	0,03
Met.noise, expl	1,66	0,08	0,26	0,08	0,14	0,13	0,04	0,00	0,05	0,09	0,05	0,00	0,02
Ghosts, expl	1,32	0,07	0,29	0,08	0,18	0,16	0,04	0,00	0,04	0,13	0,05	0,04	0,03
Ghosts, cont	0,82	0,04	0,11	0,05	0,12	0,10	0,04	0,00	0,03	0,06	0,03	0,10	0,03
Factor 2 - Fear/exploration	0,20	0,01	0,11	0,02	0,34	0,31	0,05	0,00	0,01	0,01	0,01	0,02	0,01
Chase, fol1	1,16	0,05	0,13	0,05	0,10	0,09	0,04	0,02	0,04	0,07	0,04	0,07	0,03
Chase, fol2	1,42	0,06	0,15	0,06	0,09	0,08	0,04	0,00	0,04	0,17	0,05	0,05	0,03
Chase, gr1	0,48	0,02	0,04	0,02	0,07	0,06	0,03	0,00	0,01	0,03	0,01	0,02	0,01
Chase, gr2	0,95	0,04	0,08	0,04	0,08	0,07	0,03	0,01	0,03	0,05	0,02	0,00	0,01
Factor 3 - Chase/hunt	0,51	0,02	0,07	0,02	0,12	0,10	0,04	0,00	0,02	0,06	0,02	0,02	0,01
Dist.play, expl	1,10	0,05	0,13	0,05	0,11	0,10	0,04	0,01	0,03	0,04	0,03	0,01	0,02
Dist.play, play	0,59	0,02	0,04	0,02	0,06	0,06	0,03	0,00	0,02	0,01	0,01	0,01	0,01
Dist.play, coop	0,48	0,02	0,03	0,02	0,06	0,06	0,03	0,01	0,01	0,00	0,01	0,01	0,01
Factor 4 - Distance play	0,63	0,03	0,06	0,02	0,09	0,09	0,03	0,01	0,02	0,01	0,02	0,01	0,01
Dist.play, int	0,34	0,01	0,01	0,01	0,03	0,02	0,03	0,01	0,01	0,02	0,01	0,03	0,01
Dist.play, agg	1,00	0,05	0,16	0,55	0,13	0,12	0,04	0,08	0,04	0,05	0,03	0,04	0,03
Sudd.app, agg	0,57	0,03	0,11	0,03	0,17	0,14	0,04	0,01	0,02	0,04	0,02	0,07	0,02
Ghosts, agg	0,54	0,03	0,10	0,03	0,16	0,13	0,04	0,02	0,02	0,03	0,02	0,07	0,02
Ghosts, att	0,56	0,03	0,04	0,03	0,06	0,05	0,04	0,03	0,02	0,02	0,02	0,08	0,02
Factor 5 - Defense	0,28	0,01	0,04	0,02	0,14	0,11	0,04	0,03	0,01	0,01	0,01	0,04	0,01
Cont.greet	0,27	0,01	0,02	0,01	0,06	0,05	0,03	0,01	0,01	0,02	0,01	0,02	0,01
Cont.coop	0,56	0,03	0,05	0,03	0,08	0,07	0,04	0,01	0,02	0,03	0,02	0,03	0,01
Cont.hand	0,64	0,03	0,10	0,04	0,13	0,12	0,04	0,02	0,02	0,03	0,02	0,03	0,01
Factor 6 - Sociability	0,42	0,02	0,05	0,02	0,12	0,10	0,04	0,02	0,01	0,02	0,01	0,04	0,01
Activity	1,32	0,02	0,28	0,08	0,18	0,11	0,04	0,00	0,01	0,04	0,01	0,06	0,02
Sudd.app, rem. int	0,40	0,02	0,02	0,02	0,04	0,03	0,03	0,01	0,01	0,02	0,01	0,07	0,02
Met.noise, rem. int	0,38	0,01	0,00	0,01	0,00	0,00	0,02	0,00	0,01	0,02	0,01	0,06	0,01
Gunsh. avoid	1,32	0,07	0,28	0,08	0,18	0,16	0,05	0,06	0,04	0,00	0,04	0,07	0,03

4.4 Breeding values:

Breeding values were predicted for the six factors using model [2] and genetic trends (average breeding value per birth year) for the six different factors are shown in figures 35 to 40. Factors 2 and 4 have negative trends (factor 2 shows almost no trend), while factors 1, 3, 5 and 6 show positive trends. In the case of the second factor, fear/exploration, a negative trend is good, as this factor is composed of the variables fear and exploration/curiosity, and thus a positive trend would mean more fearful animals.

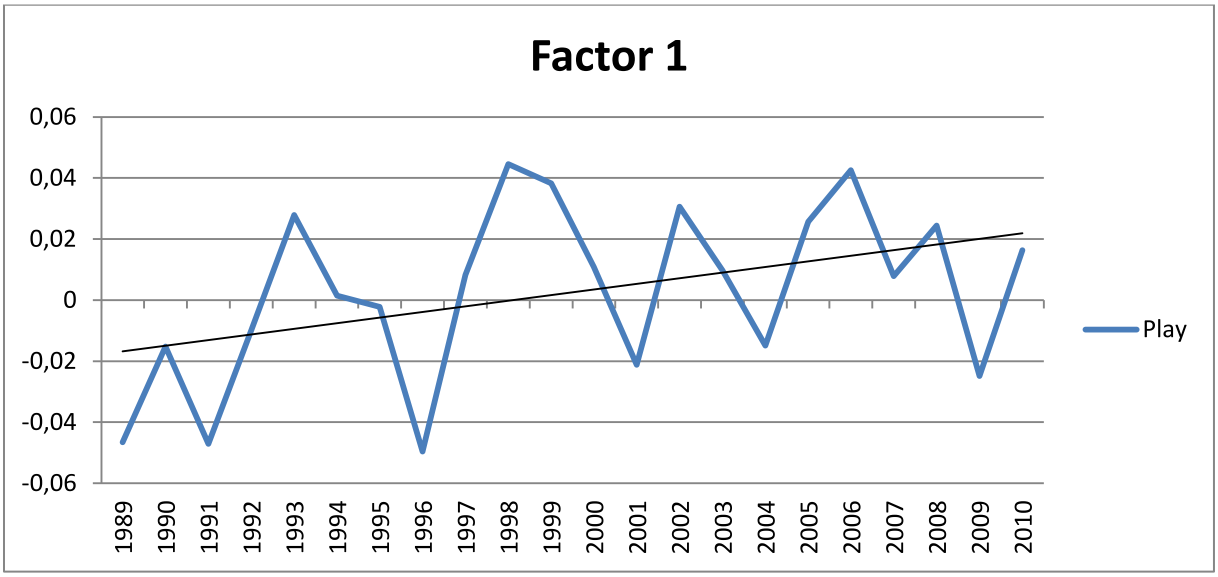


Figure 35 The average breeding values per year for factor 1

Figure 35 shows erratic fluctuations in average breeding value for the play factor, ranging from approximately -0,05 to 0,04, with a positive trend.

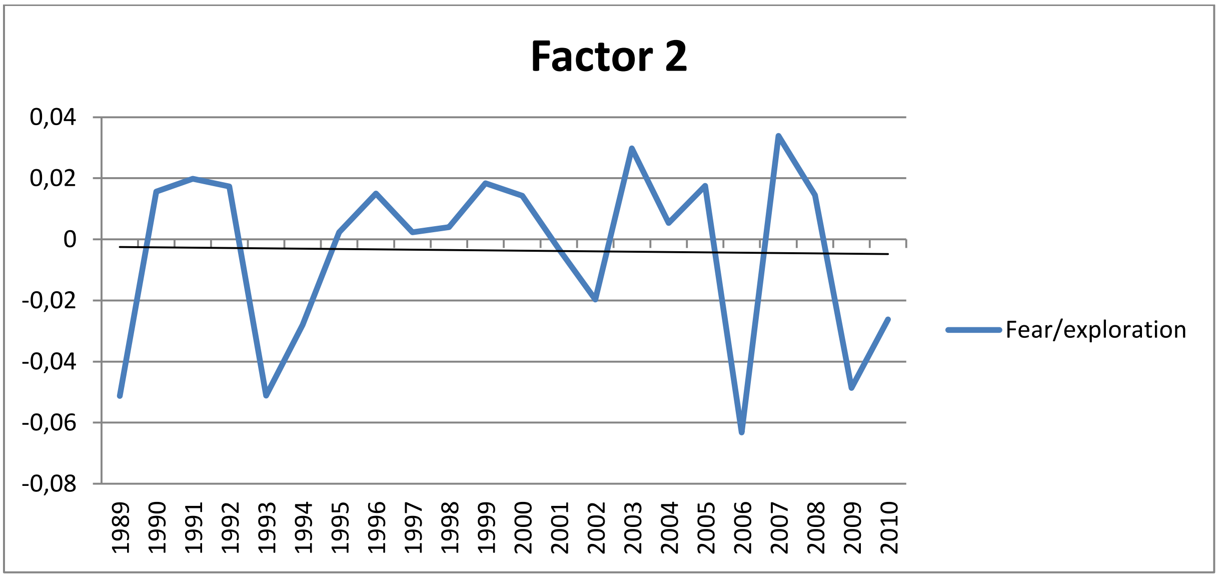


Figure 36 The average breeding values per year for factor 2

Figure 36 shows that for the fear/exploration factor, average breeding value fluctuates from -0,06 to 0,03 with a negative tendency. Between the years 1995-2005, average breeding value has mainly been positive, which in this case means breeding fearful dogs.

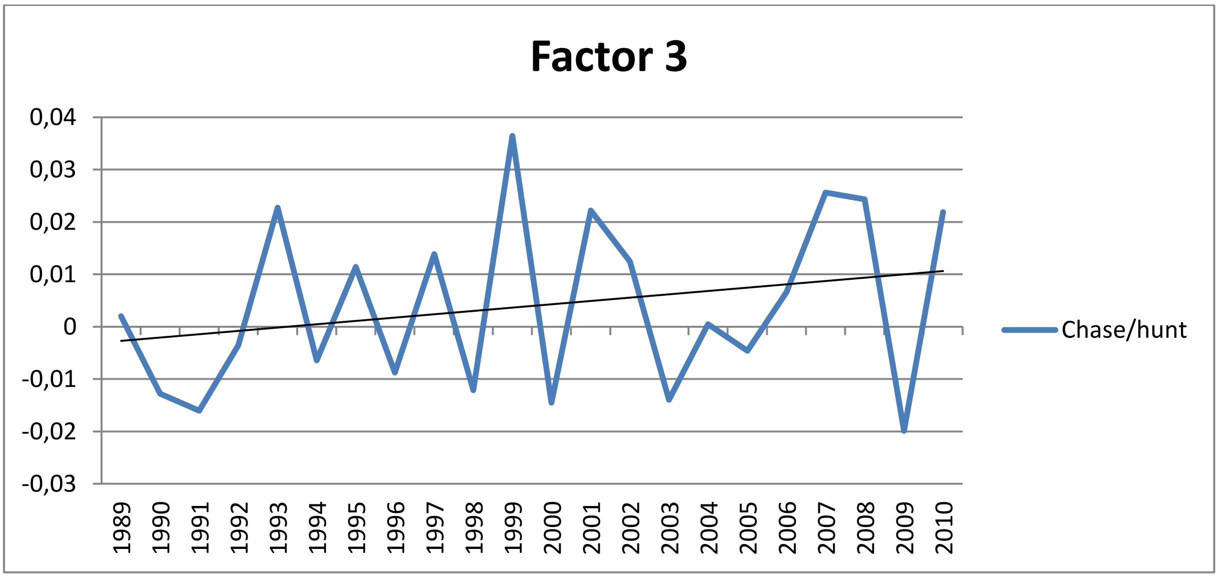


Figure 37 The average breeding values per year for factor 3

Figure 37 shows average breeding value for the third factor, chase/hunt, which ranges from-0,02 to almost 0,03, with a slight positive trend.

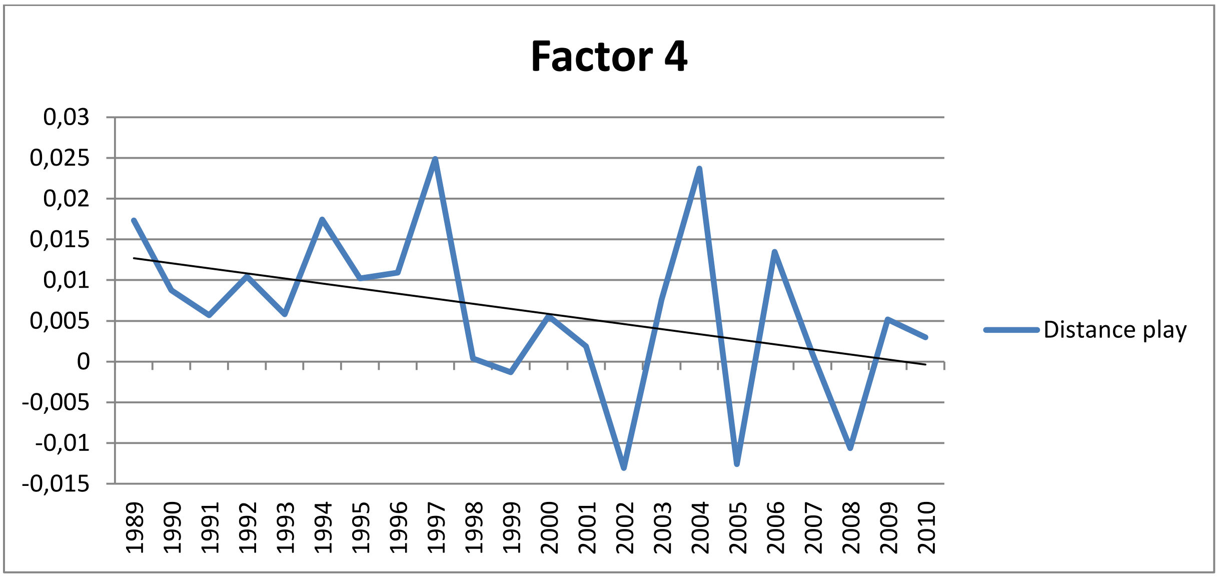


Figure 38 The average breeding values per year for factor 4

Figure 38 shows average breeding value for factor four, the distance play. The trend is negative, with average breeding values before 1998 all positive, and from 1999-2010 they fluctuate between -0,02 and 0,02.

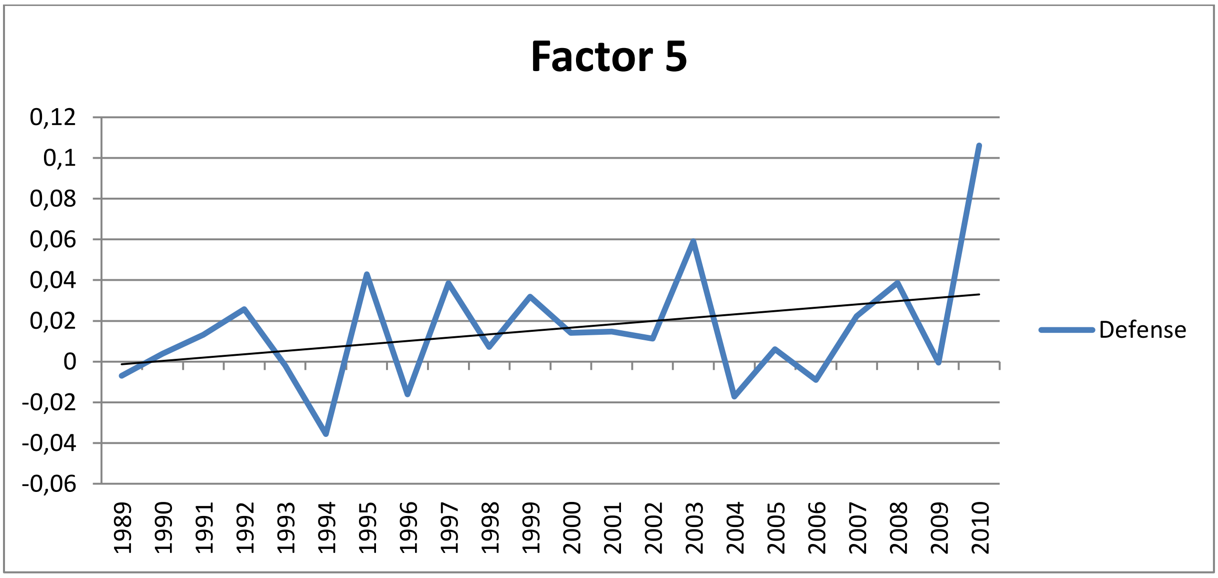


Figure 39 The average breeding values per year for factor 5

Figure 39 shows that average breeding values for the defense factor has ranged from -0,04 to 0,06 up to 2009, but in 2010 spiked at over 0,1.

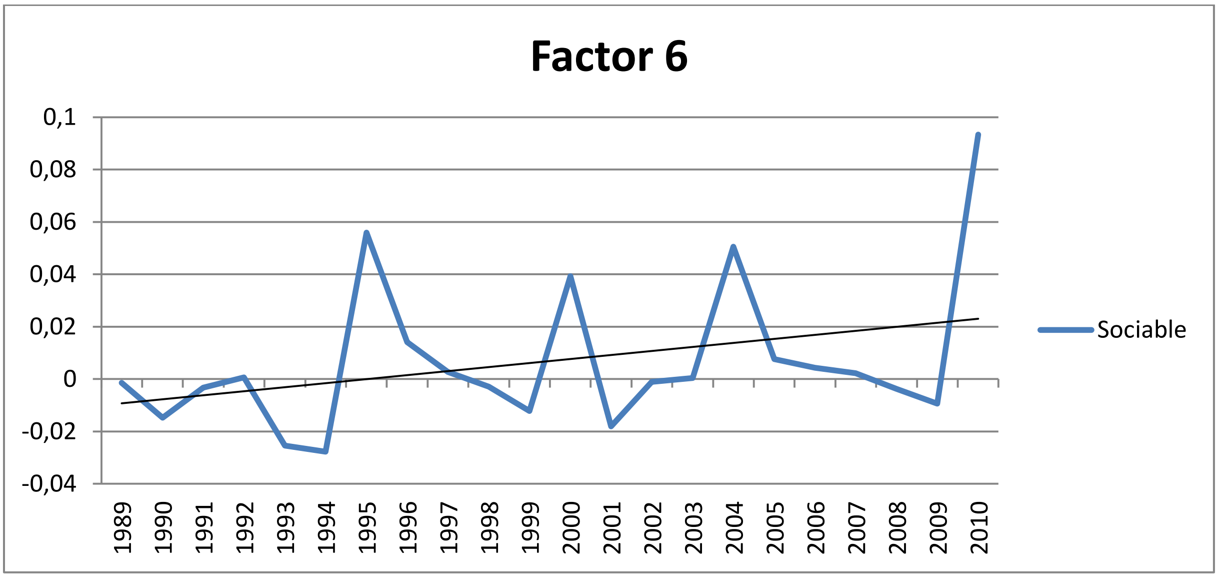


Figure 40 The average breeding values per year for factor 6

Figure 40 shows the positive trend in factor six, sociability, which goes from -0,03 to almost 0,1. Averages are primarily on the negative side before 1994. As can be seen, there is a steady decline from 2004 to 2009, but then a sharp rise from 2009 to 2010.

5 DISCUSSION:

5.1 Data:

The cohort used in this analysis is of similar size as previous studies (Blixt et al. 2010; Wilsson & Sundgren 1997a), however, the number of dogs tester per judge is in many cases very low (from one dog per judge), leading to a large number of judges, each with a low number of tested dogs. Preferably, there would be a lower number of judges testing a larger number of dogs each, as is the case in most studies using data material from the Swedish armed forces, where there are a very limited number of personnel and a large number of dogs tested, whole litters and with large half sib groups (Wilsson & Sinn 2012). Meyer et al. (2012) used a cohort of 4855 tested dogs where only 47 different judges were used. This will have large influence on the effect of the judge and since the judges in that sample were monthly trained for three years before licensing, chances are that they have a more standardized approach than judges with less training and experience. Wilsson and Sundgren (1997a) used in their test 1310 German Shepherds and 797 Labrador Retrievers from the Swedish Dog Training Centre, but did not include effect of judge in the model, and only used results from dogs tested between 450 and 600 days to exclude the effect of age. De Meester et al. (2011) have investigated the use of the Socially Acceptable Behavior test on behavior and posture, and they used a group of 171 dogs with the same group of people in the same location. This is possible with such a small number, and in controlled environments, but when testing privately owned dogs, litters may be distributed over large areas of the country, and in some areas there might be very few dogs of the same breed, which contributes to the large amount of judges with few tested dogs in this sample.

5.2 Model:

Because of the large number of fixed and random effects, the result of each effect is small, and as a conflict between including all environmental influences, the different effects may be overlapping, stealing information from each others. This may particularly be the case for the three effects concerning time of testing; year, month and specific time of test. Year of testing is important, as this effect will include refinements of the test which the SWDA continuously does to improve accuracy and objectivity of the test. But this will also be reflected in the effect of the judge, as he will adjust his evaluation according to the refinements or new standards. Since most judges operate at his local club, their material of tested dogs will reflect local breeders, many of whom will test their litters simultaneously. In these cases, effect of judge, litter and specific test situation will all be interrelated.

Specific time of testing is nevertheless very important, as this effect takes into account all the different figurants and personnel, the specific public, the specific dogs tested earlier that day and all other external influences that is restricted to that particular test place, day and situation. As Strandberg et al (2005) found, litter effects had larger influence than the genetic and environmental effects of the mother on four traits derived from DMA test results of a large cohort of German Shepherds, this result is assumed to be valid for other breeds as well.

Effect of test year and test month was significant for a very low number of variables. Meyer et al. (2012) showed that in their sample, judge and year of testing was highly correlated and so they used judge to represent year of testing as well.

5.3 Heritabilities:

The heritabilities found here is in line with heritabilities found by van der Waij et al (2008), Saetre et al (2006), Arvelius, Fikse and Strandberg (appendix 5 in (Blixt et al.) 2010), even if some of the traits/behaviors are difficult to compare directly. Ruefenacht et al. (2002) lists the heritabilities found in a wide range of studies on a variety of traits, where the highest heritabilities are 0,58 for nervousness in Labrador Retrievers and 0,51 for temperament also in German Shepherds. Wilsson and Sundgren (1998)reported heritability of 0,53 ±0,13 for activity in German Shepherd puppies.

5.4 The DMA:

A assumption for the implementation of a mentality test as a tool in breeding is that it is widely used with high numbers of tested dogs and that a number of the tested dogs are related, preferably with large paternal and maternal half sib groups and whole litters tested. It is important that the scales used for scoring are all used in scoring the behavior and that the variables tested are correctly identifying the behavior they are supposed to address (Barnard et al. 2012; Bram et al. 2008; Taylor & Milts 2006). If all dogs tested get the same score there are no possible ways to analyze variance. This has been criticized with the DMA, that the scores on some of the variables are very skewed and that some of the scores have very low percentage (Appendix 4 in Blixt et al (2010)). For some variables, this may be reflecting that this test is inaccurate in displaying the variance in this behavior and that the variable needs to be scored differently or might be omitted from the test. Such rephrasing and refinements have been done from time to time in many tests (Arvelius et al. 2013; Strandberg et al. 2005).

In this material, some of the variables have skewed scores, such as the two play subtests, where very few dogs score 5 on these variables (figures 6-8 and 31+32). This is breed specific though, Trenkle Nyberg (appendix 4 in Blixt et al. (2010)) shows that for 19 breeds, 12%, 5% and 16% get a score of 5 on the play 1 elements a,b and c respectively. For Ridgebacks in this sample, these numbers are 4%, 2% and 3%. For the distance play interest, the total breed percentage on score 4 and 5 was 11% and 4% and for Ridgebacks 5% and 1%. There was more aggression towards the distance play figurant among Ridgebacks than the other breeds on average, while 6% of ridgebacks scored 5 on this element, only 2% of the other breeds did. While only 7% of the Ridgebacks scored a 4 and 5% a 5 on the exploration of the distance play, the numbers for all the other breeds on average was 12% and 26%.

This highlights that although some variables might need refinement of the scales, in most of the cases we are seeing breed differences, and this may reflect breed problems in some cases. For the aggression towards the distance play figurant, Ridgebacks scores are similar to those of the Groenendael, and 20% more of the Ridgebacks than the Groenendaels never approach the figurant.

As the DMA was initially created as a test for potential working dogs for military or police use, it has been criticized for being of less importance for the many breeds defined as or held as family dogs. Nevertheless, quite a few of the non-working breeds have a significant number of dogs tested with the DMA, like the Bernese Mountain Dog (n=1814), Soft coated Wheaten Terrier (n= 1240), Standard Poodle (n=693), Dalmatian (n=404) and Cocker Spaniel (n=372) (Data from SKC's database; http://kennet.skk.se/avelsdata/Index.aspx). If one behavior targeted in a test is fear, there has to be stimuli strong enough to evoke fear in dogs, and the sudden appearance, the metallic sound and the ghosts do just that. The handling part of a test needs to be reflecting a dog's acceptance or aversion towards handling, and so the potential harshness of these elements may be in conflict with dog owners wish to promote their stud dog as good natured.

On the other hand, safety of personnel is of highest concern, which makes aggression towards people or dogs hard to test. There are several tests designed to identify aggressive dogs, like the SAB (De Meester et al. 2008; De Meester et al. 2011; Planta & De Meester 2007), Meet Your Match TM, Safety Assessment for Evaluating Rehoming TM and Assess-A-Pet (Bennett et al. 2012). These tests are all attempting to replicate situations where the dog could show aggression, such as towards owner, strangers, children, other animals or dogs, or food or toy possessive aggression. Using dogs with a known history of either aggressive behavior or no previous aggressive behavior, Bennett et al. (2012) found that one test identified an aggressive dog an classified it as such, 4,1 times more often than it had false positive results with a non-aggressive dog. The other test had only 1,5 times this probability. Another study found inconsistent results between three different types of test and concluded that the validity of these tests used for assessing behavior Swiss dogs should be interpreted with care regarding their significance in evaluating aggressive behavior (Bram et al. 2008). This study used the same dogs for all three tests, but these dogs had no known behavioral history. Van der Borg et al. (2010) found that even if the SAB test identified some aggressive dogs, it failed to do so when the dog behaved aggressively in the absence of fear, and therefore they recommended either a refinement of the test or addition of test components in order to target these forms of aggression.

When looking at the distribution of scores on the contact elements (figure 3-5), as many dogs have a score of 2 as of 4 on the handling element (n~500). A score of 2 means that the dogs pulls away or seeks contact with its handler when physically examined. Although such a dog most likely will not be interpreted as a dangerous dog, it is still likely in today's society that a dog will encounter strangers that wants to pet and caress it, and for a dog not comfortable with this such situations might enforce stress and discomfort upon the dog.

One problem with the DMA being designed as a test battery with 10 subtests in predefined order is that the order of the subtests may influence the outcome of the next subtest. The three potentially most fearful subtests in the DMA is the sudden appearance, followed in direct order by the metallic noise and the ghosts. For a dog with high levels of fear from the sudden appearance, this could be retained in the dog and influence the result on the next subtest, or maybe even building up inside the dog over time. For the dogs in this material, this seems not to be very relevant when the metallic noise test is considered, as the remaining fear on both the sudden appearance and on the metallic noise is on average just above 1 (figure 34). On the other hand, the dogs are generally less playful at the second play subtest than at the first, which may indicate an existing load from the previous subtests. This is similar to the findings of Trenkle Nyberg (appendix 4 in Blixt et al. (2010)), where most breeds showed a reduction in play intensity at the second play subtest compared to the first.

The large number of elements scored in the DMA may represent a practical problem for breeders when selecting for behavioral traits. Firstly, the traits with very low variety in scores all breeds considered, like the two remaining interest variables, could be removed from the test. When the dog is already scored for remaining fear, the interest is of less importance, and is probably of very little importance in both real life and as a trait in breeding. Secondly, the activity is also relatively inconclusive, not reflecting any problem behavior in the dog for those who test their dog on basis of a behavioral problem, and not measuring any potential trait for practical breeding concerned. These are also the elements that fall out in all factor analyses done, and so possess little information necessary in order to assess a dog's behavior or genetic background (Blixt et al. 2010; Svartberg & Forkman 2002).

5.5 Factor analysis:

Six factors were retained on basis of eigenvalue>1, as few as possible variables remaining unexplained by the factors and loadings of the variables upon one factor only. This is one more than what is used by the SKC for all breeds, but according to the results of Svartberg and Forkman (2002) some breed groups would fit the five-factor model and some breed groups the six-factor model with the distance play variables in a separate factor (FCI group 7 and 9, pointers and companion dogs/toys). For this data material, five factors would leave one more variable unexplained (contact handling), which would be in violation of the criteria.

The implications of the chosen six-factor model used in this analysis compared with the five-factor model used in other studies across breeds, would be that the three distance play elements would be placed in the play factor in the five-factor model instead of forming a separate factor, and breeding values predicted for the play trait would include variables with no loadings on the factor, possibly conflicting between two traits. When breeding for playfulness, there would at the same time be a selection towards animals that seeks strangers (in the distance play situation), which may be in conflict with the desired traits in some breeds, such as the Ridgeback.

For the Ridgeback, the breed standard says that this dog should be aloof with strangers but not aggressive or shy (FCI 2012). This is a term open for subjective interpretation as to how an aloof dog will react to handling or strangers, and of course of the subjective considerations of the breeder when selecting breeding material. For the typical working breeds, Sophia Trenkle Nyberg found in 2009 that 21-44% of these dogs would seek the figurant without hesitation and only 16-40% of the dogs would never approach(appendix 4 in Blixt et al. (2010)). For the Ridgebacks in this sample, this number is 4,8% and 69% respectively. In the same report, Trenkle Nyberg analyzed differences in DMA results for dogs that had been filed as class A at show or competition (unacceptable behavior) and/or bitten/damaged people severely, and they differed significantly from other dogs on all the contact variables, the distance play variables and the startle reactions on sudden appearance and metallic sound. From a comparison between how dogs behave in daily life (through a questionnaire to their owners) and their results on a DMA, Frida Johansson found in 2008 that dogs that were aggressive in home environment did not approach the distance play figurant at the DMA (Blixt et al. 2010). When investigating the behavioral characteristics shyness/confidence, De Meester et al.

(2008) found that the SAB test could distinguish between dogs showing fearful or confident body postures in response to the different test situations, resulting in a division of these dogs into two groups according to confidence. A confident Ridgeback that explores strange situations and is willing to play or cooperate with strangers will by these results definitely not be fearful and aggressive.

The defense factor consists of the aggression elements of the sudden appearance, ghosts and distance play, plus the distance play interest and the ghosts control. In previous studies, this factor has been labeled aggression, but considering aggression more of an active approach and in this test situation more of a response to stimuli, the term defense was best suited. This factor may reflect a dog's ability to and proneness to guard his owner or himself, and would be an important criterion if this breed were to be used as a guard dog.

The chase factor may or may not be an indicator of proneness to chase animals. Arvelius found that for rough collie, the genetic correlation between the owners grading of a dogs engagement in chasing and the DMA trait chase was 0,73 (SE=0,13) (personal communication, 2013). On the other hand, Johansson (appendix 4 in Blixt et al. (2010)), found a correlation between the chase elements and the play elements, so without any further analysis, this trait has an unknown basis in the Ridgeback.

5.6 Breeding values:

The breeding values predicted are ranging from -0,60 to 0,75 for factor 2 (where negative is considered good) and from -0,55 to 0,63 for the other factors. For practical use, breeding values for the fear/exploration trait would benefit from being transformed so that a high score/value is considered better (Meyer et al. 2012). Interestingly, this factor is the one with the highest heritabilities, ranging from 0,1 to 0,34 (h^2). High heritability will, together with high selection intensity (SI) and genetic variation, lead to genetic gain for a trait.

For sociability, the average score of the Ridgebacks included are around 3 on all three elements, which describe a good natured dog with balanced greeting and accepting to be handled by a stranger. A very high score on either three of the sociability elements would be considered negative, as the dog would be overwhelmingly interested in and too eager when contacting people. Thus, a neutral breeding value for a dog on this trait will mean that it will not breed above or below the average.

Svartberg (2002) and (2005) found that high boldness scores related to good performance in working trials and can predict behavioral responses like interest in play, behavior with strangers and non-social fear. High boldness score consist of high curiosity/exploration scores, low fears and high play scores. Analyses by Turcsan (2011) on genetic relatedness when considering trainability and boldness placed the Ridgeback in a group of dogs showing these traits: "low calm, high trainable, medium sociable, low bold". Low boldness may indicate missing working dog abilities, but it may also reflect lack of confidence and higher fearfulness (Saetre et al. 2006).

In other animals, production animals particularly, breeding goals would be expressed with different weighting of different traits, and the genetic gain would be a product of the heritability, the SI and the efficiency of the generation interval (shorter interval, higher gain). This is possible when there is a higher goal, decided by either economic interests or set by an overruling identity, like the cooperation managing the Norwegian Red. It is hard to identify a singular or a few limited breeding goals for mentality traits in a dog breed, as there are subjective interests as to what traits are regarded positive and negative.

The SI in most dog breeds, and the Ridgeback is no exception, differs very between the sexes. For males, SI may be rather high, with the abundant use of so-called breeding matadors, siring many litters each year and fathering a high percentage of the registration numbers. In females, the selection criteria lays in the hands of the particular breeder, as so to speak all offspring will be registered in the Kennel Club, even when the parent(s) suffer from diseases like allergies, HD or ED. The breed clubs may inflict restrictions as to certain criteria needed for having the litter advertised with them, but in the end, if the Kennel Club will register the offspring, the puppies will sell. This means that most females might be bred, and the responsibility lies with the conscience of the owner/breeder.

Lewis et al. (2013) found that with phenotypic selection alone, prevalence of hip dysplasia in the United Kingdom had decreased for all breeds analyzed but the Siberian Husky, but they also found a very low SI, in Ridgebacks equivalent to excluding less than 2% of the highest risk animals from breeding.

Some breeders will select for some traits, and others will select for quite the opposite, each breeder having subjective goals with their breeding. Since many females will be used in breeding regardless of their behavioral traits, breeding values for the six factors may be useful for identifying those traits wanted in a stud, whether it is necessary to improve the sociability, the fearfulness or lower the defense proneness in the next generation. For many breeds, these traits may be related, as a dog with high levels of aggression on the test, may actually be very fearful, and thus one have to look for a stud who combines low fearfulness/high exploration grade with less aggression/defense.

In the rough collie, it is the gunshot fear and the general fearfulness the breeders have to address, which they will be able to trough mentality indexes based upon the factor analysis done for that breed (Arvelius 2012).

If such indexes are widely used by the breeders, chances are that some animals with very good indexes will be used frequently, and get offspring with better than average indexes too. In not many generations, very closely related animals may be on top of the lists, and inbreeding may become a serious problem. In order to avoid this, an index of kinship might have to be incorporated in the breeding values, securing that the contributions of related animals are controlled each generation.

6 CONCLUSION:

For Ridgebacks in this sample, heritabilites are of a size that makes genetic progress possible trough selection based upon estimated breeding values for the mentality traits targeted by the DMA.

The DMA is a test suited for a range of dogs, but may include some variables unnecessary for both phenotypic and genetic assessment. These may be considered removed from the test. In order to increase the usefulness for breeders, breeding values should be estimated for separate breeds on basis of a factor analysis, grouping behaviors into higher traits reflecting those behaviors. These factors may vary in number and composition between breeds, and must therefore be assessed for the breed in question.

To ensure genetic gain, SI would have to be targeted. The fastest way to do this would be through incentives from the Kennel Clubs or breed clubs, who would have to make a profile of the desired traits and scores, and also decide which scores that would be unacceptable for breeding.

The Ridgebacks of this study are generally accepting contact but on the shy side of the scale, moderately interested in playing but not very prone to pull on the item. They only follow the chase the first time and do not grab it. They show some aggressive signals towards the figurant of the distance play, but most do not approach or play with him. They get quite scared in the sudden appearance subtest, show moderate aggressive signals and few explore the coveralls without help.

They have some remaining fear that goes away with time. The metallic noise doesn’t scare them as much, and more of them approach the item with less help. They have less remaining fear and interest in this subtest. The ghosts make them display quite a few aggressive signals, and they have their attention. They are quite scared of the ghosts, do not want to approach them without help, but most accept contact afterwards. They have even less interest in playing the second time around, and 50% has no reaction at all to the gunshots.

These reactions, combined with heritabilities with means to improve breed average plus the breeding values to make selection possible suggests that this breed could improve on handling, fearfulness, exploration and interest in cooperating with a playful stranger.

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